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A PRELIMINARY CONCEPT FOR A DESIGN CRITERIA MANAGEMENT SYSTEM.(U)
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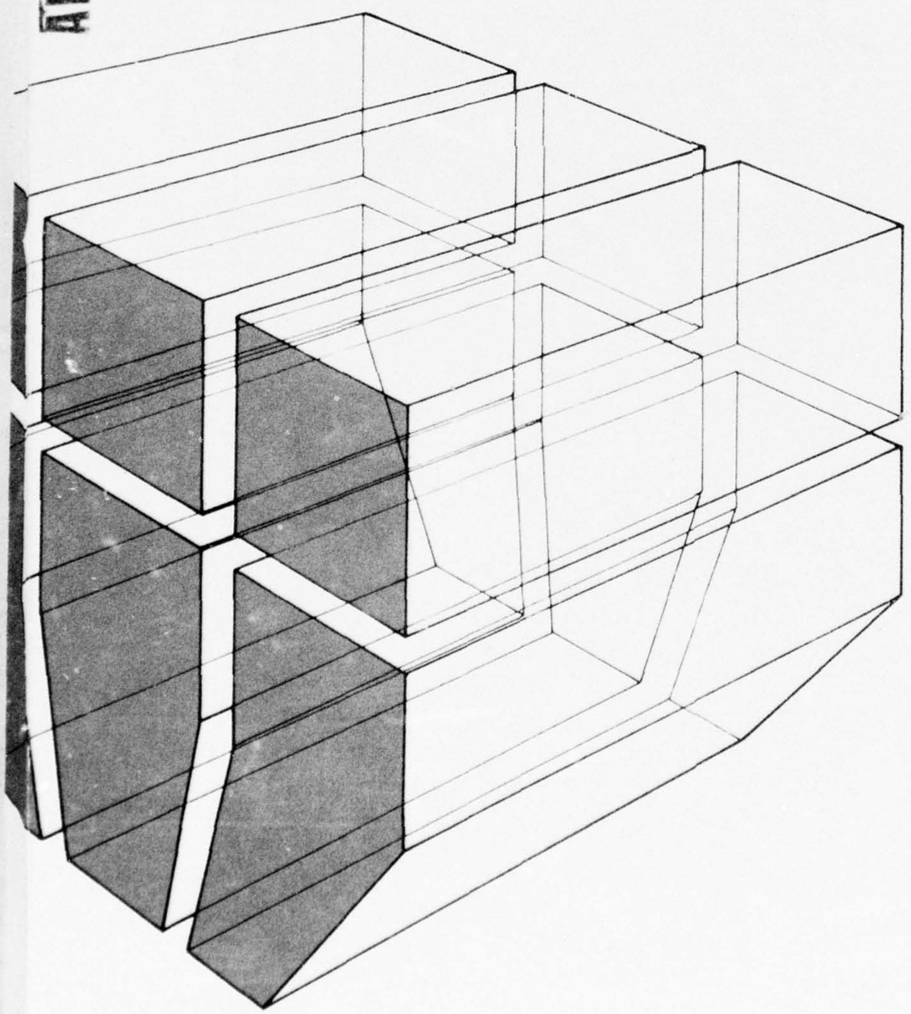
SPECIAL REPORT P-74
September 1976

A PRELIMINARY CONCEPT FOR A DESIGN CRITERIA MANAGEMENT SYSTEM

by
Michael J. O'Connor
David A. Jordani



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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) (14) CERL-SR-P-74

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER SPECIAL REPORT P-74	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) A PRELIMINARY CONCEPT FOR A DESIGN CRITERIA MANAGEMENT SYSTEM.		5. TYPE OF REPORT & PERIOD COVERED (9) SPECIAL rept.,
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) Michael J./O'Connor David A./Jordani		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS CONSTRUCTION ENGINEERING RESEARCH LABORATORY P.O. Box 4005 Champaign, IL 61820		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (16) 4A762719AT05-02-~~002~~ (17)
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE (11) September 1976
		13. NUMBER OF PAGES (12) 87p.
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, VA 22151

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

building design
Design Criteria Management System
conceptual system

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Corps of Engineers' design process relies on the relevancy and currentness of the data used in facility design and the transfer of these data to and from a variety of design and review levels. This report presents a conceptual description of an effective system for the organization, management, and communication of Department of Defense and Corps of Engineers military construction design criteria.

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The conceptual system comprises three major subsystems: (1) the Standard Design Criteria Subsystem provides for the handling, consistency checking, and production of standard design criteria; (2) the Project-Specific Design Criteria Subsystem permits the introduction of project-specific criteria and the merging of them with standard criteria; and (3) the Facility Criteria File Generation Subsystem translates the criteria into an appropriate format and relates the criteria to the design procedures.

FOREWORD

This report summarizes research conducted for the Directorate of Military Construction, Office of the Chief of Engineers (OCE) under Project 4A762719AT05, "Initial Investigation of Military Construction Technology"; Task 02, "Engineering Design Criteria and Technology for Military Facilities"; Work Unit 002, "Systems Approach to Design Criteria Format Development."

The OCE Technical Monitors were Mr. William Cochran and Mr. Robert Shibley.

The work was performed by the Management Systems Branch, Facility Acquisition Division (FA), U.S. Army Construction Engineering Research Laboratory (CERL), Champaign, Illinois. The project investigator was Mr. Michael J. O'Connor and the associate investigator was Mr. David A. Jordani. Dr. Omar E. Rood, Jr. is Chief of Management Systems Branch, and Mr. E. A. Lotz is Chief of FA.

COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Deputy Director.

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A PRELIMINARY CONCEPT FOR A DESIGN CRITERIA MANAGEMENT SYSTEM

1 INTRODUCTION

Background

Throughout the iterative phases of the building design process a wide variety of professionals with different spheres of responsibility are engaged in a continuous process of information exchange. The effective organization and communication of these data to the appropriate designer is critical in a project environment. Often, designers are given too little or too much information; in either the overconstrained or underconstrained environment, critical design decisions often fall prey to superficial approximations.

Building design is, in large part, a process of gathering, developing, and manipulating information. A project's description evolves from an initial statement of needs to the detailed specification for the objects and processes that will satisfy those needs. Designers generate information during this process by manipulating the project description and using large stores of data representing historical, current, and evolving information relative to the project. An information system for building design is, in large part, merely a specialized instance of a generalized data base management system. Even so, building information systems must deal with enough problems peculiar to the building industry to make them formidable in their own right.[1]

The development of a system to make information available to a wide variety of design professionals would not only enable designers to use more effectively the time they would otherwise spend in information gathering, but it would also help--by supporting information flow to an always current project file--to improve communication between designers through consolidation of information. Designers would be able to consider overall project goals as well as obtain the most relevant bits of data to deal with immediate problems within their specific spheres of responsibility.

Practicing architects and engineers from the private sector of the construction industry have encountered difficulty in obtaining

[1] Jeffrey J. Folinus, *The Design of a Data Base Information System for Building Design*, Research Report R73-52 (Massachusetts Institute of Technology, 1973), p 27.

design criteria.[2] Often unfamiliar with all the criteria, the architect/engineer (A/E) must filter through many references to insure proper consideration of all applicable criteria. This requirement reduces efficiency and does not take full advantage of the hired A/E design talent.

Purpose

The study presented in this report was conducted to develop a conceptual description of an effective system for the organization, management, and communication of Department of Defense (DOD) and Corps of Engineers design criteria for military construction. The development of the system had three main goals:

1. The organization of DOD and Corps military design criteria.

2. The development of a system for the effective management of those criteria.

3. The development of formats for the communication of the criteria to and from the various users that access it.

Approach

In the Military Construction - Army (MCA) cycle a number of different designers and reviewers must have access to the body of information known as design criteria. The data and usage demands that each person makes upon this system in effect act as specifications for performance of the Design Criteria Management System (DCMS). The study described here was directed at reducing the element of human error, and hence the number of inconsistencies and oversights. By collecting dispersed information into one system, communication can take place in an efficient sequence and changes can be implemented quickly and completely.

While it is recognized that a global problem exists with information transfer between the various levels in the MCA cycle, a specific subset of that global problem was chosen to provide a context for the development of a flexible system for the management of design

[2] Texas A&M Research Foundation, *A Systems Approach to Design Construction for the Corps of Engineers*, Report TR68-041/AD840174 (Office of the Chief of Engineers, Directorate of Military Construction, 1968), p 73.

criteria. The number of variables in the form of people, time, and goals involved in the MCA cycle would impede the initial development of the DCMS. While the information in the MCA cycle was not addressed in its totality, its impact on the DCMS did guide the system's development.

This study focused on the architectural and engineering design phases of the MCA cycle and the information transfer that takes place between the Corps and the A/E during the generation and approval of facility designs. Appropriately, this study addressed:

1. The demands each user makes on the DCMS during these phases, via

   (a) The nature of the functions performed by the users

   (b) The links between the proposed functional subsystems and the criteria base as determinants of information flow and appropriate formats

2. The organization of the DCMS and its integration into the design phases of the MCA cycle.

In addition, the Corps current design criteria management system (Appendix A) was reviewed to provide the context for development of the proposed DCMS.

2 MILITARY CONSTRUCTION PROGRAM

General

The Directorate of Military Construction (DMC), acting as administrator of the military construction program, is a unique client for the design profession. The DMC's methods of building procurement are necessarily different from those practiced in private industry. The military construction program that the DMC is required to manage is complex, entangled in details, and affected by innumerable constraints and impacts. At any one time, five fiscal years of program are active. While concepts are being developed for one year's program, the DOD and the Office of Management and Budget are reviewing a second, Congressional hearings are being held on a third, and the Corps is engaged in converting dollars apportioned for the fourth and fifth years into concrete and steel.[3]

Design Phases of the MCA Cycle

The design process for military construction begins with the user specifying the functional requirements for the desired facility, based on his understanding of the operations to be supported by the proposed facility. These requirements can be stated in terms of both operational characteristics of the facility and the desired human behavioral responses to the constructed facility. Operational characteristics can include such items as the physical description of specific operations and processes to be supported by the proposed facility.

Behavioral responses to constructed facilities involve such things as amounts of social interaction, mental stress, and levels of professional performance experienced by occupants, as influenced by facility environments.

The initial role of the designer is to organize and internalize the functional requirements transmitted to him by the user and to produce a design which is consistent with these requirements and other prevailing constraints. These other constraints are of two types: internal and external. Internal constraints result from a combination of the designer's education and previous professional experience that may "predispose" him toward a particular type of design model.

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[3] Texas A & M Research Foundation, *A Systems Approach to Design Construction for the Corps of Engineers*, Report TR68-041/AD840174 (Office of the Chief of Engineers, Directorate of Military Construction, 1968), p 21.

External constraints are imposed on the design through the designer's interpretation of applicable regulatory controls; e.g., the body of regulatory military guidelines.

The product of the designer's participation in the architectural and engineering process is called a design. This design is a body of information which will serve to define the scope of the work for the pending construction contract and will serve as a review document as well. The information contained in the drawings and specifications must be such that a contractor can submit an accurate bid. Furthermore, the design must be of sufficient specificity to assure that the facility is of reasonable quality and can be constructed within the budgetary limits. As a review document, the design must contain sufficient information to assure the user/client that the facility will meet all functional criteria previously established and transmitted to the designer. Finally, the design must contain sufficient information to insure that the proposed facility will meet all established regulatory standards for military construction.

Design Criteria in the MCA Cycle

The development of criteria to be used in the design and review phases of the MCA cycle is performed during two separate processes: (1) standard design criteria generation and (2) project-specific design criteria generation. It is important to note that the A/E is not part of these processes and begins his involvement with the project after all design criteria for the facility have been determined.

The sources of design criteria for military construction are so broad it is virtually impossible to enumerate them all. The transfer of the appropriate design criteria to the A/E is an important phase of the facility delivery process. While the project-specific criteria given to the A/E are relevant to the specific facility being designed, the standard design criteria are applicable to any facility of the same generic type. The burden of finding and including appropriate standard criteria in the design process rests largely with the designer.

Once the appropriate design criteria have been found, their interpretation still presents a problem. Where there is a lack of firm and definite criteria, constant changes in design occur, resulting in additional costs. Many man-hours of effort lost in superseded design result from reorganization of the project to guarantee that fund allotments have not been exceeded. On the other hand, when the criteria are too firm and voluminous, the designer operates in the frustration of an overconstrained environment and will often rely on the

standard plans provided, denying the project the benefit of his talents.

Standard Design Criteria

The design of military facilities often consists of adapting standard designs or using rigid criteria after the approval of an architectural concept. Given the complex nature of the military construction process, it will continue to be necessary to standardize design criteria, especially for application to repetitive facilities.* Standardization allows for ease of programming and budget justification, as well as for reduction of both repetitive design costs and the manpower needed to review and evaluate project designs.[4] These factors have fostered development of standard and definitive designs for site adaptation by DOD and the Army along with policies that encourage site adaptation of successful designs for special facility types.

Project-Specific Design Criteria

It is the DOD objective to provide military facilities that are complete and responsive to the functional requirements they are to support. Therefore, the design effort and the basic contract requirements for all military projects must include all those elements of facility design required to meet this objective.[5] Standard and definitive designs are accepted as a means of communicating design criteria to the various levels of design and review that take place in the MCA cycle; it is recognized, however, that they alone cannot provide enough information to foster the design of facilities responsive to the needs of the military construction program.

Military facilities are required to support a function associated with a primary objective of an organization. That is, the functional criteria for the facility are derived from the requirement to maintain

* *Repetitive facilities* are those which meet the requirements of many using services and which may be constructed at many installations and repeated at any given installation.

[4] R. W. Cramer, "Development of Space Utilization and Design Guides," *Programming for Habitability*, Symposium Proceedings (Department of Architecture, University of Illinois, 1975), p 70.

[5] *Construction Criteria Manual*, DOD 4270.1-M (Office of the Assistant Secretary of Defense, 1972).

the organization or some aspect of it at a given level of operational efficiency. In general, operational efficiency includes not only technical but also human requirements.

In an effort to improve the quality of its facilities the Army is beginning to look at the broader goals of its construction program in terms of providing environments suitable for the Volunteer Army (VOLAR) program. A new program such as this often has impact on the man-built environment, as was the case with the New Generation Barracks for which the criteria were completely redeveloped to reflect the philosophy of the new program.[6] There is evidence that the architectural environment significantly affects personnel recruitment, retention, professional performance, and personal development. Habitability criteria developed by interdisciplinary teams of architects, engineers, planners, psychologists, and sociologists need to be incorporated into military design guidelines. Facility design criteria should be developed in response to each specific project, in the context of its organizational goals (both individual and group) and functional requirements. The criteria for each individual project combined with general information from standardized criteria will support a more responsive design project.

Criteria Management

The Office of the Chief of Engineers (OCE) has the responsibility to develop, maintain, and promulgate architectural and engineering design criteria for Department of the Army (DA) facilities and construction projects.[7]

Clearly, it should be the Corps' responsibility to communicate to the A/E all design criteria that are necessary for him to satisfy his contractual obligations. It is therefore necessary that the A/E be given the appropriate criteria, consisting of a set of functional requirements and design criteria desired by the using agency, and the applicable constraints and requirements set forth by the appropriate military regulations and guide specifications.

The Design Criteria Management System (DCMS) proposed in this report provides an effective system for communicating the criteria to the various users accessing the system.

[6] Cramer, p 70.

[7] *Construction Design Approval*, AR 415-20 (Department of the Army, 1969), p 1.

Taking advantage of the designer's talents will benefit the MCA program through production of more responsive facilities. A primary purpose of the DCMS is to support this concept by facilitating the flow of information to the appropriate design/review level throughout the design phases of the MCA cycle.

3 SYSTEM CONCEPT

Design is an iterative decision process, i.e., an information flow process where the information is both dynamic and diverse. The architect is theoretically the coordinator of the various design groups, the one who integrates the solutions of the various design specialists and ensures their compatability. Since designers of building subsystems are often unfamiliar with the problems their solutions can create for others, a good deal of interaction is required to produce an optimal design. Frequently, nonoptimal solutions are agreed upon in one area to reach what is intuitively felt to be a better total design solution.[8] An important function of the proposed DCMS is the role it will play in integrating the design process by fostering the flow of information to a variety of interacting professionals.

Automation

While this system could be developed for manual operating procedures it is felt that, in view of the volume of data involved, computerization is a more realistic alternative. The ability to array and interact with thousands of conflicting criteria currently involved in architectural and engineering design along with added criteria and parameters to be absorbed from new social and technological research is far beyond the manual capacity of the practicing A/E.

Admittedly, several factors inhibit use of the computer by design professionals; notably attitudes toward design, a knowledge gap between architects and computer scientists, and the economics of information handling. Those who say the design process is intuitive and subjective show skepticism and resistance when suggestions are made to computerize all or part of it. Many architects and related professionals are as yet unaware of the computer's application potential within their own industry. Computer scientists unfamiliar with architectural problems often tend to widen this gap by presenting applications programs totally unacceptable to the profession.[9] However, some architects and engineers recognize that much of the design process is actually analysis and verification; these phases, because of their inherent ability for systemization--taken in context of the large numbers of variables to be interrelated--can be improved through computerization.

[8] J. J. Folinus, *The Design of a Data Base Information System for Building Design*, Research Report R73-52 (Massachusetts Institute of Technology, 1973), p 112.

[9] Folinus, p 16.

The economics of information handling can present a problem. Each design activity uses a sizable amount of project data. To computerize these activities, a designer would have to prepare all such data for computer input, a cost which is unjustifiable for most singular design activities. However, when these data are used for a variety of projects, the development of large amounts of reference data makes it economically appropriate to computerize the data base because the cost can be spread out over several projects.[10]

The evolutionary nature of project information offers the chance for data preparation to be more effectively used; once entered or developed within a computer, an information system can make data available for a variety of activities over the life of a project. Computers are useful, then, in the building design process because of their capacity for organizing much of the information for a design project into one system.[11] Such systems offer the potential to unify the design process.

It should be stressed, however, that the primary concern of this research is to provide capabilities that will provide a productive and flexible tool in the Corps' design criteria management process rather than to devise techniques that are most efficient in terms of computer technology.

DCMS Data Base and Computer Software Development

The major functional subsystems in the Design Criteria Management System require resources in varying quantities for both development and maintenance of a data base and computer programs (software).

Data Base Development

For each major functional subsystem of the DCMS that requires the development of a data base to support its functional area, the following activities may be required:

1. Format Development: For each data base or major portion thereof, the data in the base must be organized in a particular format (also referred to as data base design). At this point in the development of the DCMS consideration must be given to interrelationships

[10] Folinus, p 16.
[11] Folinus, p 18.

among the data elements, with particular regard to the access of data items of interest to more than one application area or module of the DCMS. Frequency of access and volume of data in each access must be analyzed so that the organization supports efficient operation. The design of the data base will also impact on the hardware and software requirements of the computer system.

2. Data Index Scheme: Some of the data bases in the DCMS will be extremely large. To minimize the time necessary to locate data elements in the base, an indexing scheme must be developed so that total average access time is minimized. The index design must also consider hardware and software and portability of the data base from one computer system to another. A major consideration in the index design will be the requirement that the cross-referencing schemes for the major functional component interface with each other. This aspect of the data base design becomes extremely important whenever components are integrated into a total system.

3. Standardized Data Element Definition: A standardized definition must be prepared for each element in the data base. These definitions will prevent ambiguities among the data elements. Reference to the proper data element will be greatly facilitated through use of standard definitions in subsequent software developments.

4. Data Collection Procedures: For each data base, procedures must be established to initialize the values of the data elements and to keep them current. Examination of current and proposed data collection procedures will reduce redundant collection points.

5. Data Coding and Keypunching: Data required to initialize and maintain the base must be coded and keypunched before they can be stored on digital equipment. Plans for accomplishing this task must be included at the time of the data base design.

Computer Software Development

Each major functional component of the DCMS requires software development. This software will support the associated functional area of the design criteria management and communication process.

1. User-oriented Language: User-oriented languages may be required for each major functional component. A user-oriented language is a set of commands similar to the language used in the associated functional area. These commands are processed as input to a program coded in high-level language (e.g., FORTRAN) and translated into computer-based procedures. This type of language is the most transportable user-machine interface available in digital computers.

2. Command Definition and Design: For each command in the user-oriented language, standard definitions must be provided. This process is analogous to developing rules of grammar for a language. It includes interpretation of the string of symbols in a command and determination of its correctness or error. Appropriate defaults and error messages must be provided for possible command errors.

3. System Programming: For each correctly or incorrectly identified command, a certain amount of computer code must be activated to act upon a data base or perform some type of computation. Planning the flow of such computer-based procedures is the integral part of the system programming.

4. Systems Coding: Each computer-based procedure must be coded in a high-level language (FORTRAN, COBOL, PL1, etc.). The code must be efficient and maximize use of language features that are transportable.

System Operation and Maintenance

For each major functional component of the DCMS, an analysis must be made of the resources required to operate and maintain the system. The analysis must include hardware requirements necessary to support software and data base operations, as well as personnel requirements for hardware operation and software maintenance.

DCMS Organization

Data Base Requirements

The Design Criteria Management System (see Figure 1) requires development of a structured data base to organize the design criteria. The concept used to determine this structure emerges from a characteristic thought pattern of the design process. This pattern emerges from the human mind's inability to concentrate on large amounts of data simultaneously. Experts generally indicate that around five to ten items are the most that can be focused upon at one time. Thus, in the design management process, with problems containing hundreds of thousands of criteria, the designer needs to conceive of groups of elements as subsets of the total situation. Then each subset may have its own subset, etc., until the smallest elements are reached. This process moves down a hierarchical structure, beginning with the total situation, breaking it into its basic components, and then breaking its components into subcomponents, and so forth. The final base of information ranges from the finitely defined space in terms of its

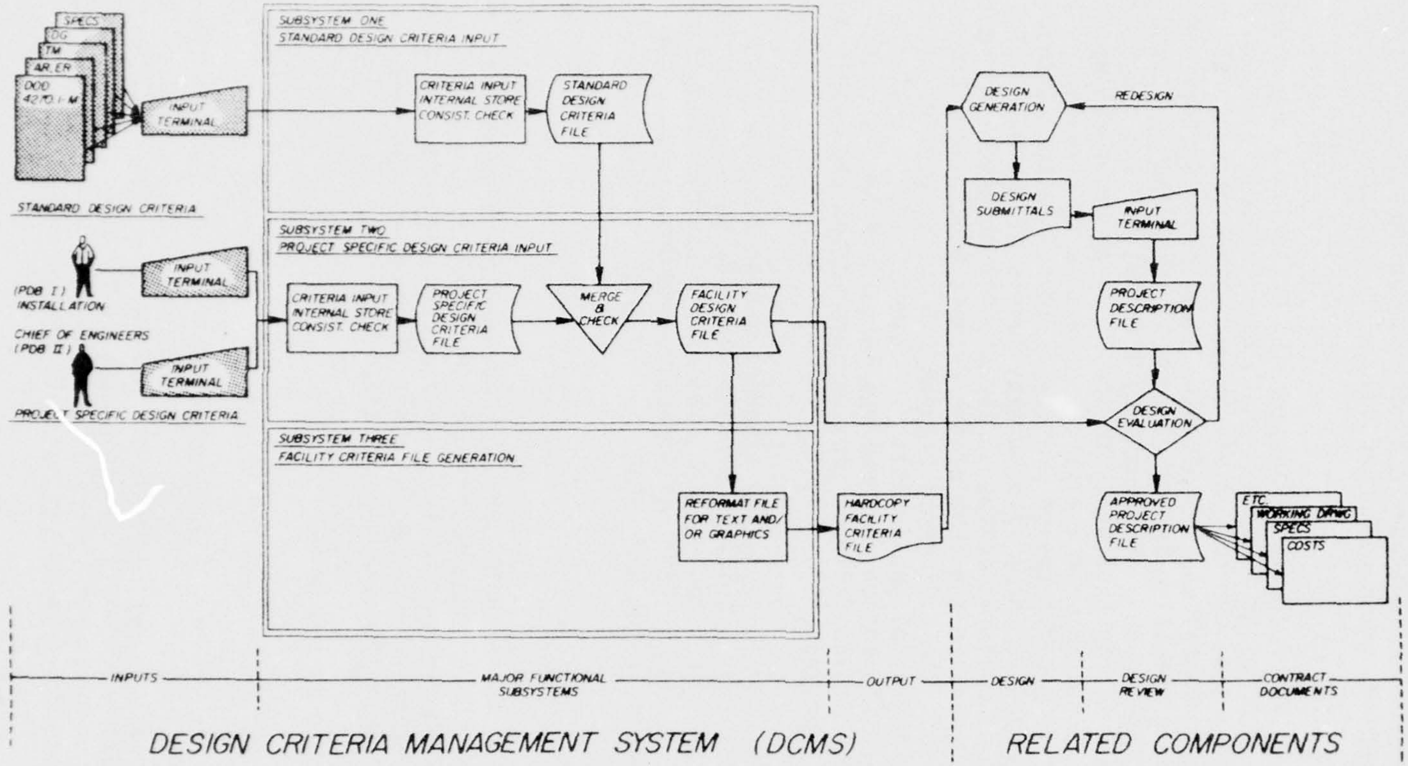

Figure 1. Design criteria management system data bases: standard design criteria and project-specific design criteria.

building components to the human activity common denominator (such as eating, sleeping, dressing) depending on the situation pursued by the designer.

Initially, two broad classifications of criteria have been identified: "Standard Design Criteria" and "Project-Specific Design Criteria." While some overlap exists between these classes, the basic purpose of these classifications dictates independent systems and procedures for their operation and maintenance. The Standard Design Criteria exist as the body of regulatory information that the A/E must search to find criteria that apply to the facility being designed. The A/E is not provided with a list of applicable criteria as he is with the Project-Specific Design Criteria. In the latter category the client (who can be identified at many levels of the MCA cycle) provides a set of criteria unique to the project at hand. Currently, these criteria exist in the form of the Project Development Brochures, PDB-I and PDB-II. The difference between the two categories of criteria is their degree of applicability. Standard Design Criteria provide generic information for numerous facility types, whereas Project-Specific Design Criteria provide information applicable only to the specific project.

As depicted in Figure 1, the Standard Design Criteria and Project-Specific Design Criteria provide the data base for the DCMS. They provide the inputs to the DCMS, which then performs a multiplicity of operations on the data for effective communication to the appropriate levels in the MCA cycle.

Software Requirements

In addition to the data base development, computer software must be developed to support the functional components in the system. The DCMS addresses the responsibilities of criteria management in architectural and engineering design by a set of computer-based applications in three major functional subsystems.

1. Standard Design Criteria

2. Project-Specific Design Criteria

3. Facility Criteria File Development

These subsystems perform most of their work in the planning, programming, and preliminary design phases of the MCA cycle. Operations proceed in an iterative cycle until all the appropriate criteria have been communicated to the appropriate design/review level.

In addition to these subsystems, other functional components exist that rely either directly or indirectly on the information transfer that the DCMS controls. These components have been identified as:

1. Project Description File

2. Design Evaluation

3. Cost Estimating

4. Project Specifications

The DCMS fosters the flow of information to an evaluation subsystem and thereby becomes an integral part in the operation of an integrated design system. The operations that take place on the project description file* require that the DCMS provide the evaluation subsystem with a set of allowable criteria combinations for the various subsystems within the facility. With this information the evaluation subsystem can produce a verified project description file which becomes the common data base for a set of interrelated computer programs that can, among other things, produce cost estimates and generate project specifications.

Subsequent sections will describe the tasks involved within the subsystems and will address the demands that each makes on the design criteria management system. Finally, a synthesis of these requirements will define a set of criteria to guide development of the DCMS.

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* The *project description file*, at any given point in time, reflects the amount of design development that has occurred, the results of previous evaluations, and the results of the design process to date. It can exist as, among other formats, a set of drawings or a series of computer-readable statements.

4 DCMS FUNCTIONAL SUBSYSTEMS

The three major functional subsystems that comprise the design criteria management system have been termed:

1. Standard Design Criteria

2. Project-Specific Design Criteria

3. Facility Criteria File Generation

This section describes each of these subsystems, using as guidance the outline for data base and software development presented in Chapter 3. The discussion will not adhere directly to the format of the outline; rather, an effort will be made to cover all relevant topics in the course of a discussion related to the functional role of the specific component.

The description may neglect certain topics presented in the outline. This could occur for either of two reasons: the topic may not be applicable to the specific component being described, or the level of research accomplished under a certain topic may not justify any definitive statements.

Subsystem One--Standard Design Criteria Input (Figure 2)

Standard design criteria for all DA projects are the responsibility of the Chief of Engineers.[12] These criteria provide guidance for design and construction of functional, durable facilities which have reasonable and appropriate maintenance and operating costs over the design life of the facilities.

Standard criteria exist in various formats in a variety of documents including DOD manual 4270.1-M, *Construction Criteria Manual*, DA technical manuals in the TM-5-800 through 899 series, numerous Army Regulations (AR), Engineering Regulations (ER), and Guide Specifications for military construction. Also, OCE has recently introduced Design Guides (DG) as a means of criteria communication.

[12] *Construction Design Approval*, AR 415-20 (Department of the Army, 1969), p 1.

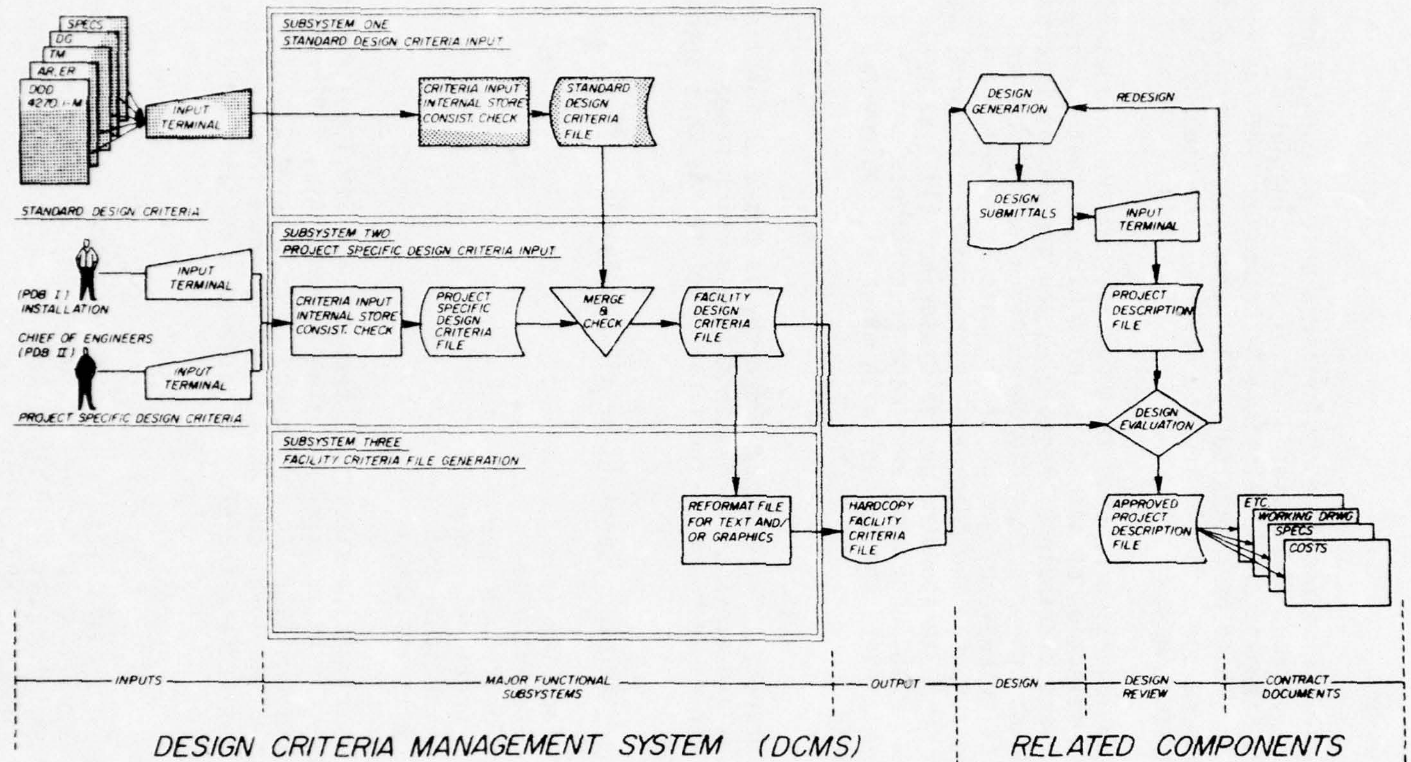

Figure 2. Subsystem One--standard design criteria input.

Data Base Development

The data base for standard design criteria must be capable of not only handling the current DOD criteria but of providing for simple integration of new standard criteria. This fact implies that the format for the data base should be suggested by the nature of existing and evolving standard design criteria and the way they are used by the designers who access them.

Design is an iterative process that consists of the manipulation of space and the selection of materials and equipment that specify its functional and image attributes. Faced with the problem of interrelating the hundreds of criteria that may be involved with a project, the designer needs to conceive of groups of elements as subsets of the total. For this purpose, two conceptual hierarchical structures will be developed to organize standard design criteria: (1) a spatial hierarchy to deal with functional and image requirements and (2) a building components hierarchy to deal with material, equipment and technical criteria.

Spatial Hierarchy. The spatial hierarchy is based on functional space differences and consists of distinct levels which range in logical steps from the broad scope of the first level to the most specific functional space.

The proposed hierarchy consists of six levels:[13]

Level I	Facility Type
Level II	Spatial Type
Level III	Functional Type
Level IV	Functional Group
Level V	Functional Space
Level VI	Activity Space.

The first level of the structure, termed "Facility Types," categorizes facilities by their major functional and spatial differences; e.g., administrative office facilities are seen as being significantly different in both functional and spatial requirements from shop maintenance facilities and are therefore considered a distinct category.

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[13] The Engineers Collaborative, Ltd., and Harry Weese and Associates, *A Proposed Hierarchical Structure of Functional Spaces for Buildings*, Special Report P-75 (U.S. Army Construction Engineering Research Laboratory [CERL], 1976), p 3.

This level of structure relates readily to what is often referred to as "building type" but is intended to go beyond that concept to include more aspects of a project than the building alone. Both programmers and designers commonly focus in on projects from this initial stand. It also sets a valuable context in which to review the preliminary project designs.

The type of criteria that would be located under each Level I Facility Type is that which is pertinent to all such facilities in that category. The information would pertain to the facility in general and would include:

1. Philosophy and policy for the facility type

2. Intended use of the specific facility

3. Relationship of the facility to its surroundings.

The second level of the structure divides each facility type into two spatial categories--interior and exterior. This provides a natural division of current information and criteria. It also relates well to normal project programming procedures which distinguish between site and building requirements, and is compatible with most design procedures.

Information and criteria located under these Level II descriptors will be pertinent to all such spaces in the category and include:

1. Spatial type philosophy and policy; e.g., two- or three-story building with a maximum of 10,000 square feet; or criteria for height to width and length ratio; or area criteria.

2. General description of the type of enclosed or open functions; e.g., the facility will include separate structures for repair shop, inspection and point storage; or incorporate provisions for a new sanitary lift station, parking lot, and two new tennis courts.

The third level of the proposed structure divides each of the Level II spatial types into two functional categories--primary and support/services. The following list displays the type of information and criteria to be located under these Level III Functional Type categories:

1. Information identifying the users and a general description of their functions and relationships

2. Quantities of user groups

3. Information that distinguishes between categories

4. Basic philosophy of the functional type.

Thus, this level provides the next logical step in degree of detail used by both the project programmer and designer. A relatively small body of written information or criteria exists for this level, probably because much of such information is provided verbally in the form of clarifications and explanations. The need to document this type of information is supported by this level.

The fourth level of the structure, termed "Functional Group," divides each of the Level III Functional Types into categories of spaces distinguished by the similarity of functions or activities which occur in each space. For example, one such category on this level is "Residence." Under that category are grouped the numerous living spaces associated with housing, as opposed to office spaces, which have been grouped under the "Administrative" category. The type of information which would be listed under a Level IV descriptor includes the following:

1. The basic intent and philosophy of the functional group.

2. Specific criteria that pertain to all spaces within that functional group; e.g., criteria stating that all ceiling heights in administrative offices shall be 10 ft or that lighting levels shall be 100 footcandles.

3. Relationships between functional groups; e.g., criteria that would separate the administrative (office spaces) in a training facility from the actual training rooms or classrooms within a facility, or, conversely, integration requirements stating the need for combining administrative spaces with research spaces in a particular facility.

This level of the structure performs two important functions. First, it provides a natural location for a body of information and criteria which is too often unrecorded and which is passed on verbally in the form of clarifications and explanations. This situation is primarily characteristic of the first and third types of information. Second, it provides a natural location for a large body of existing information and criteria that deals with broad categories of spaces.

This Level IV Functional Group should prove a valuable source for schematic design review by the Corps and installations, while providing the A/E designer with an important set of information which he

would normally request or generate if it is not provided. It should also prove valuable to the programmer of a more unique type of project by providing a natural grouping of all similarly functioning spaces; e.g., a grouping of all "Administrative" space types on the levels below.

The "Functional Spaces" of Level V of the proposed structure act as the next natural subset of the hierarchy. This level of the structure is intended to categorize information pertinent to the room level of functions and spaces. Information anticipated under this set of descriptors may prove to be the most extensive of any of the levels. It is likely to include:

1. Precise area, occupancy, and functional criteria
2. Environmental criteria such as temperature, humidity, and light
3. Adjacency criteria
4. Safety and convenience criteria
5. Service and utility criteria.

Most programming efforts that deal with categorizing information for functional spaces use some form of descriptor similar to the functional space level. A/Es commonly use such a category in design, and it will undoubtedly be useful to the reviewer as a result.

The sixth and lowest level of the proposed structure provides a level for categorizing information that deals with functions and spaces at the subroom level. This lowest level of the proposed hierarchical structure will provide considerable flexibility to the structure as well as keep the Level V categories within manageable quantities. Level VI categories have been termed "Activity Spaces." They deal with spaces within functional space where distinct, discernable activity takes place; e.g., a student seating area, or a teaching station within a classroom. Without them it might be necessary to classify separately each of a group of classrooms as a unique functional space. Level VI Activity Space categories are intended to be used to define the unique activity spaces of each otherwise duplicate functional space, thereby permitting the several functional spaces to be described as one. For example, two "briefing rooms" may differ only in the requirement that one also provides a lecture platform at one end for assembly functions; use of a Level VI Activity Space category in the hierarchy will permit a single Level V descriptor, "Briefing Room."

It is anticipated that the following types of data will be stored on this level:

1. Activity criteria

2. Unique furniture and service utility criteria.

Appendix B presents the functional space hierarchy for one facility type--bachelor housing. Although not exhaustive, the appendix presents an example of how the hierarchy would be used to organize spaces and their associated criteria for this facility type.

Building Component Hierarchy. In the process of communicating design criteria it is necessary to link information from the spatial hierarchy with information that pertains to materials and equipment specifications. These criteria are needed by the A/E to design the space-defining elements (i.e., floors, walls, furniture, etc.) in the facility. This link is a logical evolution in the organization of design criteria, since formal definition of spatial volumes (and consequently the design) is not complete until the space-defining elements (i.e., building components, equipment and materials) have been specified.

The building components hierarchy will consist of several different levels that relate to material specification and selection. Each level will represent a successively more specific decision in the building design process, from the highest level specification of the general system criteria (e.g., electrical criteria, mechanical criteria, etc.) to the lowest level representing the basic construction task. Each system may contain several levels of descriptive detail, such as shape, design, principal material, secondary material and coating.

The design criteria will be categorized into eleven major divisions or systems. These criteria are further subdivided into as many levels as necessary to reach the basic construction task. The proposed eleven divisions with their first and second levels are presented in Table 1. The appropriate data element definitions would contain information on the product, its design and application.

An extension of the descriptors to be contained in the hierarchy is presented in Appendix C. The structure displays a segment of the component descriptors needed for roofing design (Division 05).

Table 1

Building Component Hierarchy: Tri-Services Uniformat

Division	Level I		Level II
01	FOUNDATIONS	011	Standard Foundations
		012	Foundation Excavation
02	SUBSTRUCTURE	021	Slab on Grade
		022	Basement Excavation
		023	Basement Walls
03	SUPERSTRUCTURE	031	Floor Construction
		032	Roof Construction
		033	Stair Construction
04	EXTERIOR CLOSURE	041	Exterior Walls
		042	Fenestration (Doors and Windows)
05	ROOFING	051	Roof Covering
		052	Insulation
		053	Flashing
		054	Special Construction
06	INTERIOR CONSTRUCTION	061	Partitions
		062	Interior Finishes
		063	Specialties and Fittings
07	CONVEYING SYSTEMS	071	Elevators
		072	Escalators
		073	Special Systems
08	MECHANICAL	081	Plumbing
		082	Heating and Ventilation
		083	Fire Protection
		084	Special Mechanical Systems
		085	Air Conditioning
09	ELECTRICAL	091	Distribution
		092	Lighting and Power
		093	Special Electrical Systems
10	EQUIPMENT	101	Furnishings
		102	Fixed Equipment
		103	Special Construction
11	SITEWORK	111	Utilities
		112	Paving
		113	Walks
		114	Curbs and Gutters
		115	Fencing
		116	Storm Drainage
		117	Unusual Foundations
		118	Site Improvement
		119	Demolition

Linking the Hierarchies. As an organizational concept, the building component criteria can be nested into the spatial hierarchy at any appropriate level. Division 4 of the component hierarchy nested into Level I of the spatial hierarchy might contain criteria governing the type of brick and methods of construction for the facility in general. Division 06 linked to Level V or VI would contain criteria about interior finishes for specific spaces or activity settings within the spaces, respectively. It is believed that most component criteria will be stored under Levels V and VI of the spatial hierarchy.

A comprehensive system for the management and communication of design criteria must also deal with certain contingency factors that govern facility design, such as location, climate, personnel strength, and geometric description of the facility. These factors exist as a series of variables that apply to many of the design criteria in both hierarchies. To include these contingency factors in the hierarchies would require that they be duplicated wherever they are relevant; this would make the data base unnecessarily large and complex.

A series of parameter files will be developed to manage these variable contingency factors. These files will be indexed throughout the hierarchies when appropriate. The nested hierarchies with their references to the parameter files should provide a comprehensive capability for the organization of standard DOD criteria.

Accessing the design criteria from the structure will occur in different modes. The system design will provide the capability for accessing criteria at any level of the hierarchies. This capability will be accomplished by standardizing the definitions assigned to the design criteria elements. Each design criteria will be accessed by correctly specifying the unique data element definitions assigned to the criteria. For example, specifying BOQ (Level I Spatial Hierarchy) and ELECTRIC (Division 09 - Building Component Hierarchy) will transmit electrical criteria for all spatial types in a bachelor officer's quarters facility. A more detailed discussion of accessing design criteria will be offered later.

Summary of Data Base Development. The preceding discussion describes the basic structure for the organization of standard military design criteria for the proposed Design Criteria Management System. It will serve as the basic organizing element for criteria for Subsystem Two--Project-Specific Input and Subsystem Three--Facility Criteria File. Necessarily, Subsystems Two and Three will require additional capabilities that will be developed as extensions of the basic DCMS data structure.

Software Development

The software that will be developed for Subsystem One will perform several functions. As the criteria are manually input through a terminal the programs will perform a check to insure consistency within the information. Using the standard element definitions, the software will compare the criteria appropriate to the definition, check for conflict and/or redundancy, and store the criteria in the proper location in the nested hierarchy. To do so the criteria must be stored in a format that allows comparative evaluation by the computer. The format to be used is the conditional expression. The equivalent machine-logical expressions will serve as the internal (to the computer) representation of design criteria and will precisely notate all objective information. Criteria with variable performance requirements* will also be stored this way. Certain criteria, specifically those that cannot be translated into conditional expressions, will not be stored in this format, but will be kept as verbal text.

In addition to eliminating conflict and redundancy from the standard criteria, the programs will manipulate the criteria into a boolean (the internal machine equivalent of the conditional expression) format and store them at the appropriate location in the hierarchy. A procedure will be established to insure that criteria are assigned to the appropriate data element definition in the hierarchy.

After the initial effort, standard criteria will be reviewed systematically at regular intervals. To enable this procedure, a series of commands will be defined in the form of a user-oriented language.

Operating as a stand-alone module, this subsystem could immediately improve the organization of design criteria. Changes to criteria could be implemented quickly and completely by accessing the appropriate level for each facility as it is initialized in the hierarchy. Similarly, criteria could be accessed from the data base by specifying the appropriate element definition in the hierarchy. The criteria would be communicated in their internal machine format until some type of output function converts the data into a more usable format; this conversion function will be discussed under Subsystem Three.

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* *Variable performance criteria* are those design criteria that are determined on the basis of a specified parameter value; e.g., the design criteria for the number of parking spaces for a facility are determined by the number of personnel attached to the facility.

Subsystem Two--Project-Specific Design Criteria Input (Figure 3)

Specification of the functional criteria for each project is the responsibility of the using agency.[14] These functional criteria include:[15]

1. Justification of project from mission requirements

2. Facility siting

3. Functional flow diagrams

4. Performance requirements

5. Space requirements

6. Special equipment requirements.

For each line in the 5-year defense program, the using agency must be prepared to submit firm criteria to the Corps. These criteria must be complete to minimize changes, delays, and additional cost, and must be in agreement with standard DA criteria and approved master plans.[16]

Currently, the project-specific criteria are presented in the form of a Project Development Brochure (PDB). The using agency presents its criteria in PDB-I, while OCE presents criteria in a somewhat different format in PDB-II. Subsystem Two will provide the using agency and other responsible levels of the MCA cycle with an opportunity to present design criteria that will be pertinent solely to the facility at hand. These criteria will be merged with the standard criteria from Subsystem One, which contains generic information for all facility types. The object of this merge procedure, and Subsystem Two, is to produce a comprehensive design criteria file for the project.

Data Base Development

As the project criteria are input by the using agency an

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[14] *Construction Design Approval*, AR 415-20 (Department of the Army, 1969), p 2.
[15] *Construction Design Approval*, p 2.
[16] *Construction Design Approval*, p 15.

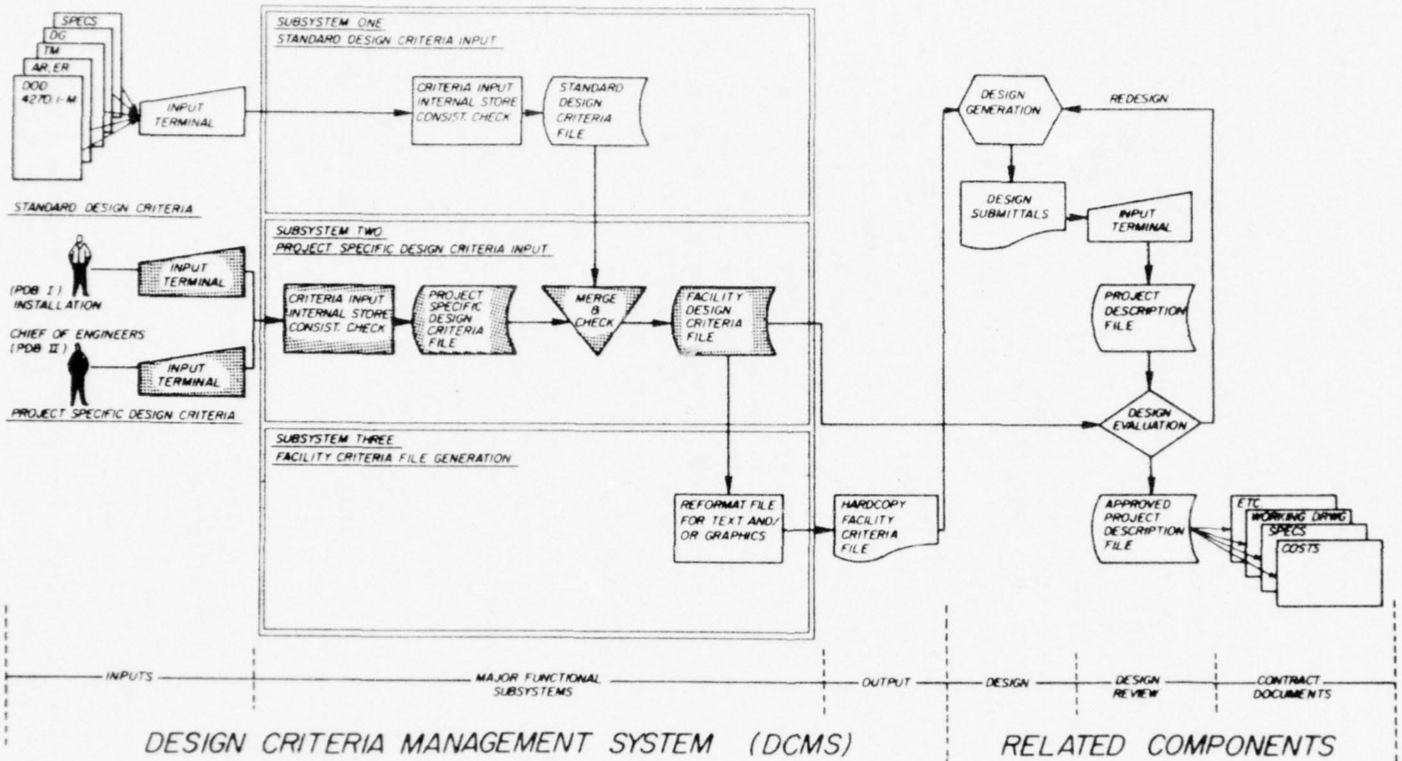

Figure 3. Subsystem Two--project-specific design criteria input.

opportunity is presented to modify the design criteria data base to further clarify the communication of design criteria. The issue of criteria interpretation has been considered a major problem by architects and engineers who have designed military facilities.

Questions consistently come up regarding the binding authority of the military criteria: specifically, which criteria are regulatory and which criteria are guidelines--i.e., nonregulatory in nature. In the private sector, an A/E confers with a client to establish the goals and objectives for a project and the criteria to be used in the design. In addition, local codes and regulations precisely specify the regulations that must be observed and the requirements that must be met in the design and construction of a building. The architect works with the client and develops an implicit hierarchy of responsibility for implementing the criteria into the process.

Criteria used in military designs should be communicated in the same manner. In the MCA process the A/E is not involved in the planning or programming of repetitive facilities and enters the process after the project design criteria have been developed. The criteria should be presented to him with attributes specifying the degree of regulatory authority they possess. In the MCA process regulatory authority is influenced daily by decisions at many levels. The negotiation of the architect's responsibility for implementation of specific criteria should be determined by the responsible levels at the time they enter their criteria for the project into the system. This function will be of special importance when a user's criteria conflict with standard DOD criteria.

A separate data base will be developed to organize the project-specific criteria. The format for the data base structure will be the same as the standard criteria format to allow the merging of the two data bases in a logically consistent fashion (this merging procedure will be discussed in the next section). The same data-element definitions for the hierarchial structures of the Subsystem One data base will be used for the Subsystem Two data base. Note that since project-specific criteria represent a subset of the body of standard criteria the data base will be smaller.

Appendix D examines the feasibility of converting military design criteria into the proposed formats for the development of a computer-based design criteria management system.

Software Development

The functional aspects of Subsystem Two require a set of programs that will perform consistency checks on each source (PDB-I and PDB-II)

of project-specific data, and merge that data with a file of standard criteria for the facility to generate a file of design criteria for the project. This file would consist of all the appropriate standard criteria merged with the project-specific criteria as presented by the user.

During the generation of this facility criteria file a series of operations will be performed on the data. Initially, the user criteria (PDB-I and PDB-II) will be checked against each other for conflict and redundancy. Since many users influence facility design, this operation could take place over a computer network, with the users accessing a common data base from remote terminals. Procedures would be established to resolve issues of conflict in criteria in a vastly reduced time period.

Consideration will be given to development of a series of routines that will prompt the using agency during criteria input. This type of technique would revise the need for the Project Development Brochures since the prompting routines would vary for each facility type.

After the Project-Specific Design Criteria File is developed it will be merged with the Standard Design Criteria File. Each unique data element mentioned in the project file would be compared to its associated element in the standard criteria file. The boolean equivalents of the criteria would be mathematically compared and any violation of standard criteria would be noted. The various users would resolve the issues of conflict and classify criteria as regulatory or nonregulatory. Decisions in this regard would have to be made by the using and funding agencies.

As a stand-alone module, this subsystem would allow any echelon in the MCA Cycle to incorporate design criteria into the facility file. Integrated with the standard criteria subsystem, the DCMS would be capable of assembling design criteria files for any facility type, with the additional advantage of being able to simply and quickly change the files by accessing the appropriate data element definition.

Subsystem Three--Facility Criteria File Generation (Figure 4)

Subsystems One and Two provide the data base substance for the Design Criteria Management System. The output from Subsystem Two consists of a file of design criteria for the project--a result of merging the standard criteria and project-specific criteria into one file.

Before facility design criteria can be communicated to and

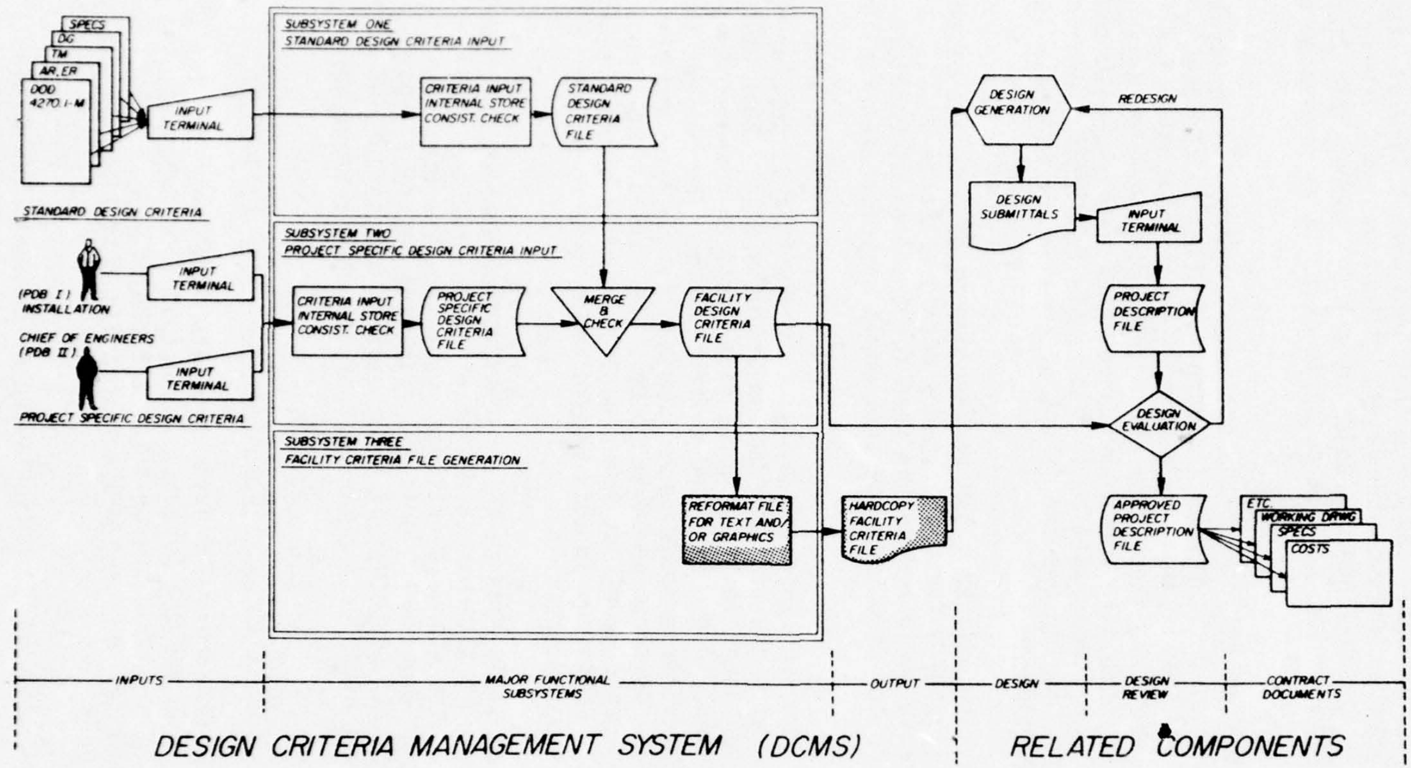

Figure 4. Subsystem Three--facility criteria file generation.

accessed by the users of the DCMS, software must be developed that will convert and interpret the internal storage notation (machine-logical) of the criteria into a format appropriate for the specific user accessing the data. The format for the criteria should relate criteria to design procedure and promote compatibility between these two elements. The appropriate format for each criteria is therefore dictated by the time-phased nature of information flow in the MCA cycle design phases (i.e., what criteria are needed by whom and when), and the state of the art in architectural program format techniques.

Data Base Development

No major data base development activities are required for Subsystem Three. The data base to be operated upon is the Facility Design Criteria File stored in the computer. It should be noted that either of the files from Subsystems One or Two could be generated as hardcopy files by eliminating the procedure required to create a merged facility criteria file.

Software Development

The initial architectural program data must be logically organized when presented to the A/E. The organization and format of the criteria should relate to design procedures. The same reasons that suggested a spatial hierarchy for the internal storage structure for design criteria apply to the organizational concept for communicating these criteria to the A/E. Subsystem Three software will be developed to organize the information into a six-level spatial hierarchy, with material and equipment criteria (from the building component hierarchy) nested at any of the six levels (but primarily in Levels IV, V, and VI).

Current trends in architectural programming recognize the value of communicating criteria in a visual-verbal format.* A large amount of text, in itself, can often confuse the user; but when this verbal information is integrated with visual information in the form of matrices, maps, and diagrams, the two forms work to reduce the level of abstraction. Initially, visual information will be provided by

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* The word *format* is used here to define the visual characteristics of the information as it is presented and not the structural characteristics of the data base hierarchies. The interest is in the communicative value of text, sketches, diagrams, maps, etc.

reference to supplementary documents; eventually, it may be possible to replace this with graphic images produced from internal machine formats.

A variety of computer programs will be developed to relate the criteria to the specific organizational level and its information requirements within the MCA cycle. Criteria for the various users of the DCMS would be formatted for design and review activities as well as for justification, budgeting and authorization.

Appendix E has been developed as a partial example of the type of document that would be formatted for the A/E to use as an architectural program. The design criteria presented in the example are for a bachelor officer's quarters (BOQ) and have been taken from a variety of sources including standard design criteria and criteria for BOQs from various using agencies. It should be assumed that each criteria has binding authority since that determination procedure would have taken place during the merging of standard and project-specific design criteria.

While visual information has not been developed for the BOQ design criteria in Appendix E, examples of possible formats to be used have been taken from a variety of sources and are collected in Appendix F.

The ability of the DCMS to produce a hardcopy version of the Facility Criteria File does not preclude a necessity for the DCMS to respond to a specific user's requests for design criteria. To satisfy this need the DCMS must have a variety of different access modes.

Users of the Design Criteria Management System will be able to access criteria in the data base by specifying the appropriate combinations of unique data element definitions. By employing a simple keyword retrieval scheme a user can access all of the criteria available for a certain facility by merely specifying the unique data element definition for that facility type; if the user wants to obtain criteria for the illumination requirements for a work station, a concatenation of the appropriate unique data element definitions will cause the system to transmit the information.

For example, the string of unique data element definitions that would generate the criteria in Appendix E might appear as:

GET BOQ & ENCLOSED & USER

This would cause the DCMS to output all criteria available on interior user spaces in a BOQ facility. The request:

GET BOQ & ELECTRICAL

would generate all electrical criteria incorporated at any level of the hierarchy, whereas the request

BOQ & DINING AREA & ELECTRICAL

would generate only electrical criteria for dining spaces in a BOQ; i.e., the requirement for a duplex outlet for eating apparatus (see Appendix E). The more unique data element definitions used on the inquiry, the more specific are the criteria that will be output.

The output-generating and access routines are key elements in the operation of the DCMS. These programs provide the interface between man and machine. The level of their sophistication will influence the use of the system and determine the degree of impact that the DCMS will have on the MCA design cycle.

5 DCMS RELATED COMPONENTS

During the information transfer processes in the MCA cycle the Design Criteria Management System is presented with two sets of criteria as inputs and produces as output a reformatted hardcopy version of the facility criteria file developed in Subsystem Two (Figure 5).

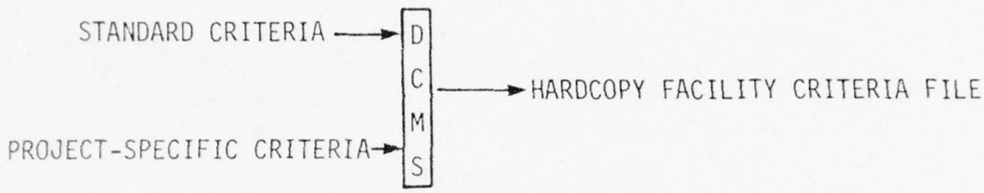

Figure 5. DCMS inputs and output.

The DCMS supports information transfer to a wide variety of functions, which are not part of the DCMS, in the design of military facilities. Figure 6 illustrates the role the DCMS would play in an integrated design system. Design criteria are an integral part of the information transfer process in the MCA cycle; they are used as deterministic elements in the process of generating a design and act as the body of information against which evaluation takes place during review cycles.

The following sections discuss the characteristics of specific functional components that could interact with the DCMS in the design process. This discussion is presented to substantiate the need for the DCMS because of its central role in the management of a common data base that is integrated into the design processes it supports.

Project Description File

In current practice the generation of a design is a manual, iterative process that ultimately produces a set of contract documents that are submitted periodically for approval by various levels in the MCA cycle. The design and evaluation procedures rely on the expertise of the individual concerned primarily with that phase of design or review for which he is responsible. This task-oriented approach, where people operate within their own spheres of responsibility, requires perfect communication between the different designers and

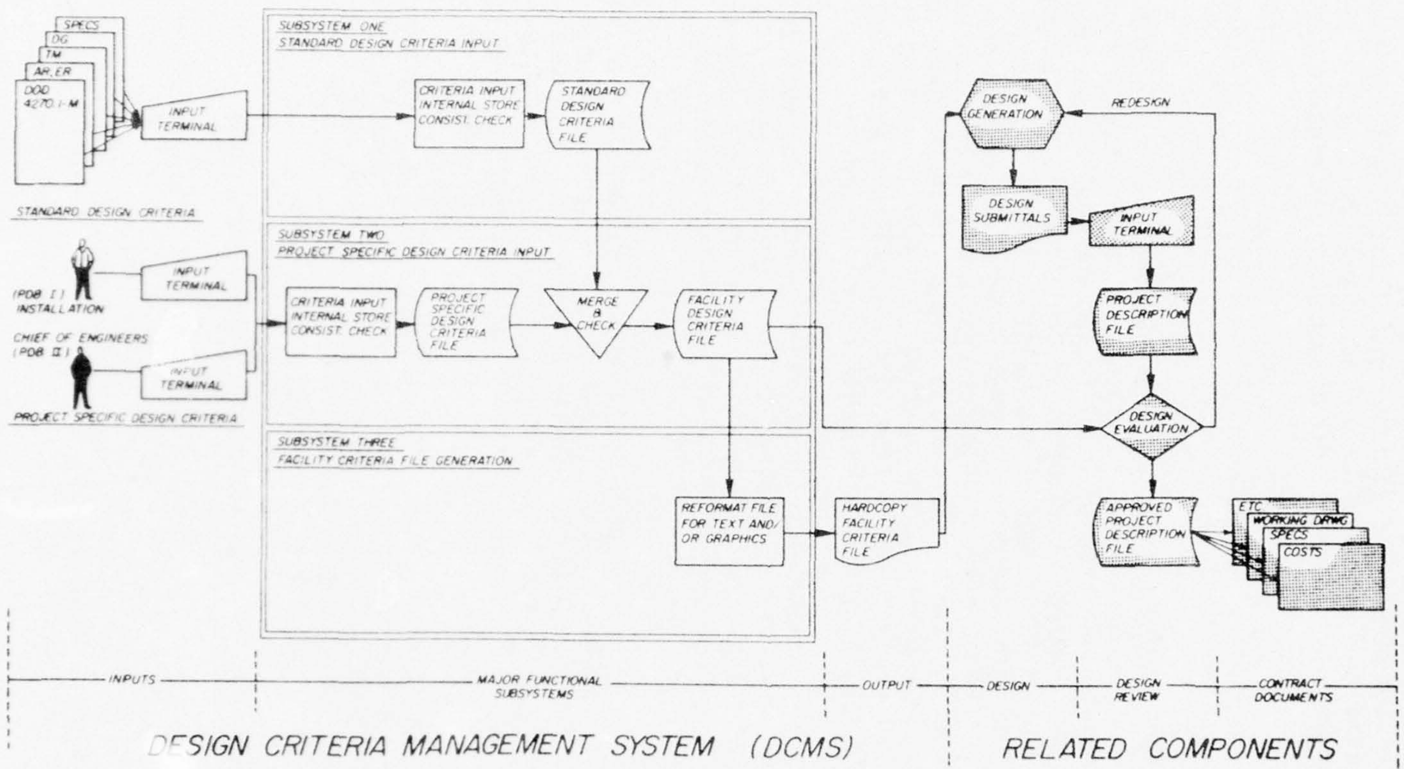

Figure 6. Related components--design criteria management system.

reviewers, since each person's decisions interact to affect the project.[17] Duplication and wasted effort often occurs when, as a result of communication delays, designers work from noncurrent project descriptions.

Data Base Development

More efficient communication can be achieved by implementing a project description.[18] Because of the nature of the building design process, the communication problem is different for each design phase. Over the course of a design, development of the information representing the project status is of special importance. Initially, a project is described by few data, and even its most fundamental aspects are in a very fluid state. As a project develops over a period of time new information further specifying the characteristics of the project is being generated. This generated information typically is derived from modification of the project description, and the analysis that generated it is also partially based on the project description.

By the final design phase, sheer volume has become the most critical aspect of the information problem; this aspect also extends through the construction phase. This evolving nature of building information makes the subject of project data management a difficult one.

As the design is developed the project description file contains information about decisions related to the spaces, materials, and equipment in the facility. In the earliest stages this file could be filled with volumes of stored background information based on history files for general facility types. Incoming design decisions would replace former "predicted" information in the project description file. An important point is that although the project description file is always in a process of modification it is always complete. Its completeness allows for incremental or continuous design iteration for a variety of different alternatives. By consolidating this descriptive information, the project description file would help to improve communication between all organizational levels of the MCA cycle.

The data base that is developed in the form of the project

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[17] Jeffrey J. Folinus, *The Design of a Data Base Information System for Building Design*, Research Report R73-52 (Massachusetts Institute of Technology, 1973), p 10.
[18] Folinus, p 15.

description file would be structured similarly to the data bases of the major functional subsystems of the DCMS. The building description, being a product of the integration and synthesis of the design criteria, would be translated into the same internal format (machine-logical boolean expressions) as the criteria and would be attributes of the same unique data element definitions. This condition is necessary to support the evaluation routines in the review phases of the MCA cycle.

Software Development

The creation of a project description file could take place in two substantially different modes. In the first, the design would proceed using manual techniques for preparation of the contract documents. Once this set of documents is completed it would be translated by a set of programs into a computer data base accessing the same data element definition and internal storage formats as in the DCMS data base. A command language would be developed to enable the user to enter statements using the vocabulary he normally uses in describing buildings. Plans could be entered by using a digital pointer or other graphic device and a new element of information--geometric--would be associated to each data element definition. This process would produce a fairly comprehensive description of the facility.

In the second mode of creating a project description file, the major portion of the design process would take place in an automated environment, eliminating some of the manual tasks needed to create a set of contract documents. By combining typewritten statements and graphical input the designer would be able as he designs the building to describe it to the computer in sufficient detail to develop a comprehensive project description. Many attempts at developing comprehensive computer-aided architectural systems have been and are being undertaken.[19]

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[19] Among others, building description systems have been developed or are being developed: C. H. Burnette, *An Organization of Information for Computer-Aided Communication in Architecture*; C. M. Eastman, *The Use of Computers Instead of Drawings in Building Design*; J. J. Folinus, *The Design of a Data-Base Information System for Building Design*; Daniel Roos, ed., *ICES System: General Description*. See Reference list for complete references.

Evaluation Component

The Corps of Engineers acts as client, contracting for design services with A/E firms in approximately 80 percent of its building program; the remaining 20 percent is designed in-house. The designs must meet all applicable design and construction regulations. The review of design submittals consumes time and manpower and will likely consume more of these resources as the design process becomes more complex.

The proposed Design Criteria Management System will reduce the design review effort in two ways. First, the organization and format of the criteria communicated to the A/E will support more responsible design effort, thus reducing the opportunity for error. Second, the creation of the project description file will support automated evaluation techniques that will perform a substantial portion of the review process.

Data Base Development

Two data bases are required to perform design evaluation; the project description file that is prepared in either of the modes previously discussed and the facility design criteria file that has been stored in the computer during Subsystem Two operation. These two data bases will have substantially the same organization and formats.

Additional data base development may be required to support some of the review techniques within the evaluation subsystem.

Software Development

The design evaluation and review procedures for the Corps of Engineers have been developed to insure the quality of the product within the limits established for its design, construction, and funding. The Corps' system of design review is one of the most highly structured set of procedures available for the review of facility designs. While certain portions of the review must be done manually, the highly structured procedures make the implementation of a computerized evaluation system possible.

The software developed in the evaluation subsystem will check design decisions against the criteria for the facility. The internal boolean notation of the design decisions as associated with each unique data element definition in the project description file are mathematically evaluated against the internal notation of the criteria

for the same data element definition in the DCMS Facility Criteria File. During the evaluation cycle, the major tasks to be performed are:

1. Review individual design decisions to reduce design errors and costly change orders.

2. Make logical checks of interdependent design to insure conformity with criteria.

3. Trace design, construction, operation and maintenance deficiencies back to their sources, or to the decisions which caused problems.

4. Maintain consistent review procedures based on the same criteria and apply these procedures throughout all districts.

The review cycle is an iterative process which can be initiated at many points in the design process. Iterations through the cycle will proceed until a solution has been verified to conform with the criteria. This approved project description file will serve as the data base for the estimating of costs and generation of the project specifications.

Cost Estimation and Project Specifications Component

These two functional subsystems are displayed as the final components in the diagram developed to indicate the role of the DCMS in an integrated design system. Their location is not intended to indicate that these functions are performed as the last step in the facility delivery process of the MCA cycle; in fact, cost estimates are required in the early phases of facility design for budget approval and authorization.

The development of these components has been the subject of an extensive research effort by the Corps of Engineers and other agencies. The components are mentioned in this report to help define the scope of work which the proposed DCMS would influence. Their treatment here is not intended to define their respective functions and accordingly will be quite brief.

Data Base Development

The approved project description file that emerges from the review cycle as a comprehensive facility description is required for

cost estimating and specifications components. In addition, a data base of material, labor and equipment unit costs and sets of multipliers or indices must be provided to the cost-estimating system. For the specifications component the military guide specs will provide the data base for the preparation of project specifications.

Software Development

The software development for these components will be directed at coupling the information in the project description file with the information in the data bases that support the respective components.

The cost-estimating component will quickly determine the effects of design changes on project costs.[20]

The specifications component will support rapid and complete editing and formatting of OCE Guide Specifications and immediately disseminate revisions. By automatically compiling project specifications, this component will reduce the human error which often results in change orders.

[20] E. S. Neely, *Construction Cost Engineering and Computation State of the Art, 1973*, Technical Report P-10/ADA022656 (U.S. Army Construction Engineering Research Laboratory, 1974), p 5.

6 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This report has presented the need for and a conceptual description of a system for effective organization, management, and communication of design criteria to be used in the MCA Facility Delivery Process. The Design Criteria Management System, when implemented, would support the information needs of the various users within the MCA cycle. It would be an open-ended system in that incorporation of new standard criteria and project-specific criteria would be possible. In addition, the evaluation of design submittals within the framework of appropriate evaluation procedures would be fostered by the DCMS.

The proposed Design Criteria Management System would serve as both a management tool and an operational tool for the Corps of Engineers facility delivery process. As a management tool, the hierarchical data base would provide a structure within which to collect, classify, and organize design criteria. As an operational tool the structures would provide ready access to the set of design criteria for the specific project or the body of standard generic criteria.

The proposed hierarchical structures would relate well to designer and reviewer and would enable each level of the MCA cycle to specify design criteria. The broad-scope to narrow-scope structure would permit the A/E to absorb the criteria in a logical way and would allow the designer or reviewer to move successively through or selectively retrieve criteria.

Recommendations

Future efforts should involve detailing the operations to be performed by each of the three major functional subsystems that comprise the DCMS. Flow diagrams indicating the file structure and data transfer and manipulation for each subsystem as a stand-alone module and as an integrated component should be developed to define the system architecture and lay a foundation for its development and implementation.

The Design Criteria Management System should be developed in a phased manner so that each major functional component will function both in a stand-alone capacity and as an element of a totally

The Design Criteria Management System should be developed in a phased manner so that each major functional component will function both in a stand-alone capacity and as an element of a totally integrated system.

APPENDIX A:

CURRENT MILITARY DESIGN CRITERIA
MANAGEMENT SYSTEM

Introduction

The basic design guides for the MCA program are DOD manual 4270.1-M, *Construction Criteria Manual*, DA technical manuals in the TM-5-800 through 899 series, Design Guides (DG) developed by the Office of Chief of Engineers, ARs, ERs, and Guide Specifications for military construction. These publications prescribe the design and construction criteria applicable to all MCA facilities. This appendix describes the activities and responsibilities of the DOD and Corps of Engineers components in the generation, application, and updating of DOD and OCE design criteria. In addition, the substantive and procedural requirements for deviations from criteria, and the responsible components, are detailed.

For clarity, the duties of each responsible component with respect to design criteria have been subdivided into four discrete functional stages: criteria generation, criteria application, criteria updating, and criteria deviation. The work flow and/or responsible component for certain types of facilities (e.g., medical installations, aviation facilities) may differ from the general case. Where applicable, these differences are noted in the text.

Criteria Generation

General

The Chief of Engineers is charged with developing, maintaining, and promulgating architectural and engineering design policy and criteria for DA facilities or construction projects. Standard criteria developed for repetitive facilities must consider economy. The Deputy Chief of Logistics provides general staff supervision of construction standards and criteria. Detailed design criteria which may be developed and used by the Defense Components must be consistent with the criteria contained in DOD Manual 4270.1-M.

In addition to the basic design manuals mentioned earlier, OCE maintains the Current Design Information System (CDI), which handles design information not available through routine channels. Design information (including criteria) developed for unique or system-critical

applications and selected design data applicable to specific design problems or facilities involving complicated or unusual applications is entered into the system and made available for the optional use of Corps Divisions and Districts. Data or information resulting from special studies, research, and engineering investigations having direct application to design is also included in the CDI.

Specific

Family housing facilities: The Chief of Engineers is to formulate any necessary supplementation of DOD criteria and disseminate copies to Corps of Engineers field offices and Army commands.

Medical facilities: The Surgeon General is responsible for coordinating the programming requirements for hospitals and medical facilities. In addition, he is to develop requirements and criteria based upon populations to be served and anticipated work loads.

Army aviation facilities: The Chief of Engineers is responsible for developing master planning criteria and space allowances for Army aviation facilities.

Safeguard: The Chief of Engineers is assigned the responsibility to develop criteria for Safeguard.

Air Force construction: The Air Force is to develop, furnish and/or define applicable criteria for the construction agent. If the Army performs the construction, the construction agent is normally the Corps of Engineers. If the Navy performs the work, the construction agent is normally the Naval Facilities Command.

Criteria Application

The criteria in DOD 4270.1-M are to be used in planning and design of (1) permanent facilities, including family housing, in the MCA program; (2) minor construction and nonappropriated fund projects; and (3) major alteration to existing structures for rehabilitation or conversion into permanent facilities. These criteria are applicable to all facilities at military installations in the United States and, to the extent practical, to other locations worldwide. The Chief of Engineers, except for standard designs, has delegated his design responsibilities to Division and District engineers.

Division and District engineers must prepare designs in strict accordance with these established criteria unless deviations described

below are authorized. Construction commanders (i.e., commanders other than the Chief of Engineers who have been specifically delegated authority to execute Army construction programs in whole or in part) are required to monitor these programs to insure adherence to established DA construction and design criteria. The Chief of Engineers is required to assist and advise the Deputy Chief of Staff for Logistics (DCSLOG) in formulation and review of the annual MCA programs and in defense of these programs before Congress; this assistance includes review of program submissions for conformance with prescribed criteria.

New or revised design criteria issued by OCE are one of three types: routine, special, or immediate. "Routine" application requires use of the new criteria in all future projects and in current projects if received prior to initiation of site adaptation of standard drawings or initiation of preparation of project drawings and specifications. All revisions to criteria are considered "routine" unless otherwise specified. "Special" application requires use of new criteria in future projects and integration into projects already designed but is applicable to the latter only if it is clear that project bidders will have time to receive and consider the changes without postponing bid opening. "Immediate" application requires integration of new criteria into all projects, including those already under construction, unless application would: (1) delay critical beneficial occupancy dates, (2) result in removal of an uneconomical amount of construction already in place, (3) result in loss of materials already delivered, or (4) require additional funding which would necessitate reprogramming of funds and would jeopardize other items already in the construction budget. The Division engineer is authorized to waive implementation of the "immediate" change in the case of Army projects if it comes within the terms of one of the above exceptions. For Air Force Projects the change must be approved by the Air Force Regional Civil Engineer (AFRCE) prior to implementation.

Criteria Deviation

General

The Division Engineer may, for a specific project, authorize deviations from OCE criteria. This authority may not be delegated. If the proposed deviation comes from the District level, it must be brought to the attention of the Division engineer at the earliest possible design phase. Division engineers in overseas areas may deviate from CONUS criteria where application of these standards is not feasible; such deviations must reflect the advantages or limitations of available materials and local construction practices. In no case,

however, does the authority to deviate extend to changes in criteria which will permit an increase in fire or life safety hazards or to changes in criteria for Army or Air Force airfield and heliport pavements. Each time the Division/Engineer exercises his authority to deviate he must promptly notify HQDA (DAEN-MCE). This report must be prompt to allow time for comment by OCE in case of an objection and to allow time for any necessary corrective action by the District at least two weeks prior to bid opening.

Specific

1. Family Housing Facilities: Any exceptions and/or waivers from criteria contained in DOD Manual 4270.1-M, except for statutory limitations, require the prior approval of the Deputy Assistant Secretary of Defense (Installations and Housing).

2. Medical Facilities: If deviations from the criteria in DOD 2470.1-M are deemed necessary because of fund limitations or other factors, proposed deviations with justifications must be sent for approval to HQDA (DAEN-MCE-A).

3. Army Aviation Facilities: The Chief of Engineers is responsible for coordinating with the Assistant Chief of Staff for Force Development, HQDA (DAED-AVO), to obtain agreement to proposed changes in space allowances or criteria. Proposed deviations from pavement design criteria and marking of operational aircraft pavements prescribed in TM-5-803-4 must be addressed through Corps of Engineers, District Engineer, channels to HQDA (DAEN-MCE-D). Deviations from airfield, heliport, and helipad lighting criteria must be addressed through Corps of Engineer, District Engineers channels to HQDA (DAEN-MCE-U), and all other proposed deviations from TM-5-803-4 criteria must be sent to HQDA (DAEN-MCE-P) for approval. However, requests for waivers relating to safety clearances, flight hazards, operational safety, and master planning are to be submitted through Army Command rather than Corps of Engineer and District Engineer channels. Requests for waiver of DOD criteria concerning Safety Flight and Noise Abatement contained in DOD 4270.1-M must be submitted through Army Command channels to DAEN-MCE-P for review and then forwarded to the Deputy Assistant Secretary of Defense (Installations and Housing) for continued action.

Criteria Update

Comments on and suggested changes to the DOD Manual and the DA Technical Manuals are encouraged from all sources; suggestions are to

be submitted to DAEN-MCE. In addition, there are two specific programs designed in part to provide data and information which will be used to revise and update existing design criteria. These are known as the Post-Completion Inspection Program and the Design Criteria Feedback Program.

Post-completion inspection occurs about 6 months after occupancy of a facility. Two purposes of the inspection are (1) to determine the adequacy of the facility, the Corps standard designs, and the Corps design criteria, and (2) to detect potential high-cost maintenance items. The inspection team is composed of OCE construction engineering and facilities engineering personnel, representatives of Districts and/or Division Engineers, the Installation Facilities Engineer, and the Major Command, if the latter desire to attend. The District Construction Division is to prepare the report of the post-completion inspection and forward two copies to HQDA (DAEN-MCE-E). Air Force projects are to be inspected only when specifically authorized or requested by AFRCE or the Major Air Command. Suggestions for improvement of design obtained from this program are to be evaluated by OCE and implemented as appropriate.

The purpose of the second program, the Design Criteria Feedback Program, is to keep OCE engineering design guidance current with the latest architectural and engineering innovations through a program of periodic OCE/Field Office inspections of military facilities which have been in use for about 3 years. Initially, visits are to be scheduled to "high-volume facilities" where exceptionally high maintenance has been reported or to facilities incorporating new subsystems of an unusual nature. Technical teams from the Directorate of Military Construction (DAEN-MC) and the Directorate of Facilities Engineering (DAEN-FE) and personnel from the appropriate Division and District offices make the on-site inspection; each team member must be thoroughly familiar with current design criteria in his area of responsibility. The OCE team members are responsible for preparing a report including recommendations for improving and updating OCE design guidance. Appropriate recommendations are to be implemented.

APPENDIX B:

FUNCTIONAL SPACE HIERARCHY

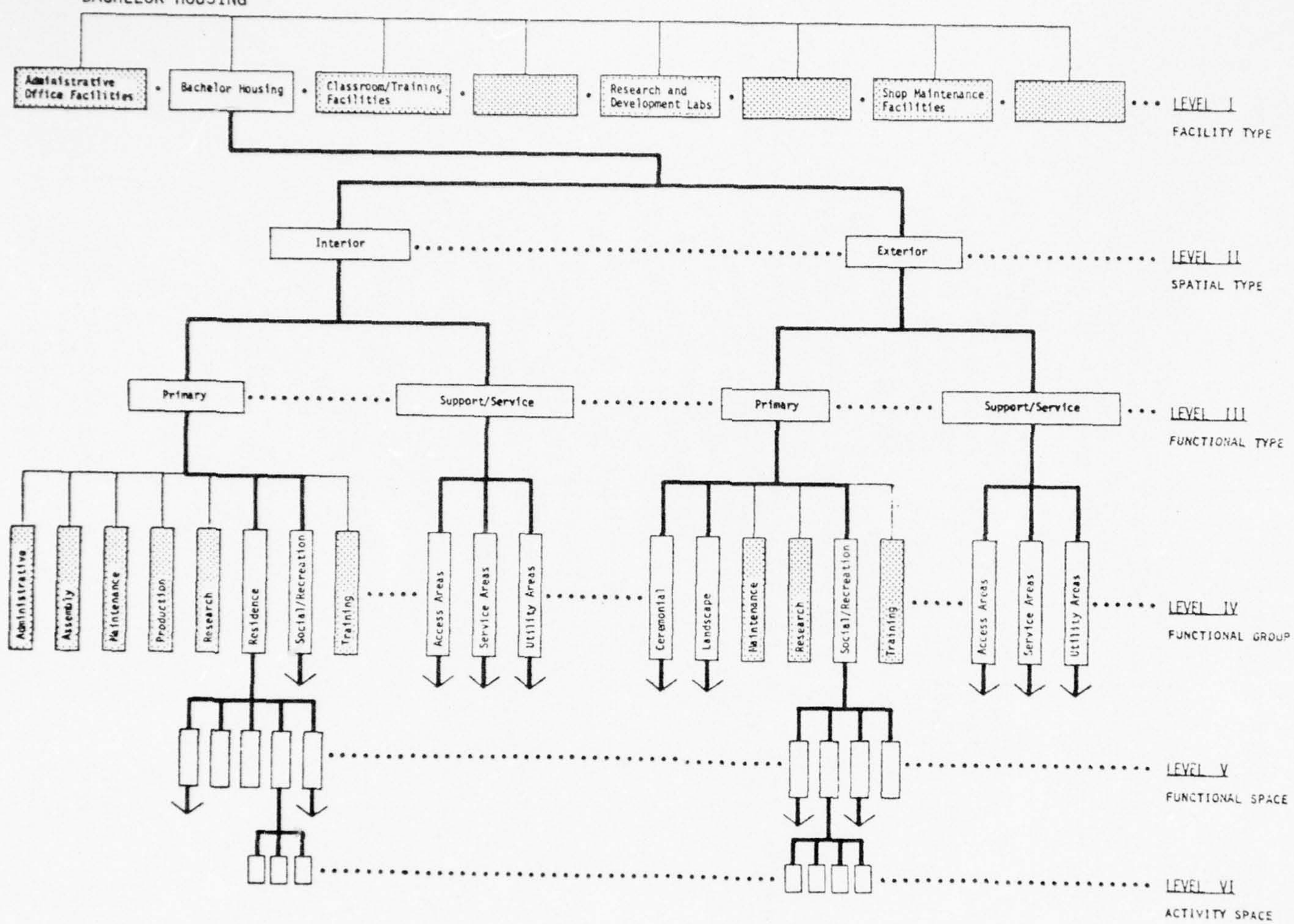
The functional space hierarchy is based on functional space differences and consists of distinct levels which range in logical steps from the broad-scope first level to the lowest, most specific functional space. The proposed hierarchy consists of six levels:[21]

Level 1	Facility Type
Level 2	Spatial Type
Level 3	Functional Type
Level 4	Functional Group
Level 5	Functional Space
Level 6	Activity Space

The following is an example of the functional space hierarchical structure with all of its descriptors for one facility type, bachelor housing. Data have been obtained from a variety of sources, both public and private, in an effort to identify and collect descriptors (unique data element definitions) for the hierarchy.

[21] The Engineers Collaborative, Ltd., and Harry Weese and Associates, *A Proposed Hierarchical Structure of Functional Spaces for Buildings*, Special Report P-75 (U.S. Army Construction Engineering Research Laboratory [CERL]), p 3.

HIERARCHICAL STRUCTURE
BACHELOR HOUSING



A PROPOSED HIERARCHICAL STRUCTURE
OF FUNCTIONAL SPACES FOR BUILDINGS

LEVEL I FACILITY TYPE	LEVEL II SPATIAL TYPE	LEVEL III FUNCTIONAL TYPE	LEVEL IV FUNCTIONAL GROUP	LEVEL V FUNCTIONAL SPACE,	LEVEL VI ACTIVITY SPACE
BACHELOR HOUSING	INTERIOR	PRIMARY	RESIDENCE	BATHROOM	LAVATORY AREA TOILET AREA
				BEDROOM	SLEEPING AREA STORAGE AREA
				CENTRAL BATHROOM	DRYING AREA LAVATORY AREA LOCKER AREA SHOWER AREA TOILET AREA
				HALL	
				KITCHEN	EATING AREA FOOD PREP. AREA STORAGE AREA UTENSIL CLEANING AREA
				KITCHENETTE	
				LAUNDRY ROOM	
				LIVING/SLEEPING AREA, E1	SLEEPING AREA STORAGE AREA
				LIVING/SLEEPING AREA, E2-E4	SLEEPING AREA STORAGE AREA
				LIVING/SLEEPING, E5-E6	SLEEPING AREA STORAGE AREA
				LIVING/SLEEPING, E7-E9	SLEEPING AREA STORAGE AREA
				LIVING/SLEEPING, GRADE 02-	LIVING AREA SLEEPING AREA STORAGE AREA
				LIVING, GRADE 03+	LIVING AREA
			SOCIAL/RECREATION	KITCHEN SELF SERVICE	KITCHENETTE SEATING AREA
				LOUNGE AREA	

A PROPOSED HIERARCHICAL STRUCTURE
OF FUNCTIONAL SPACES FOR BUILDINGS

LEVEL I FACILITY TYPE	LEVEL II SPATIAL TYPE	LEVEL III FUNCTIONAL TYPE	LEVEL IV FUNCTIONAL GROUP	LEVEL V FUNCTIONAL SPACE,	LEVEL VI ACTIVITY SPACE
BACHELOR HOUSING	INTERIOR	SUPPORT/SERVICES	SERVICE AREAS	VAULT, ARMS	STORAGE, SPARE PARTS STORAGE, TOOL WORK AREA
				VAULT, PERSONAL ARMS	
			UTILITY AREAS	CEILING CAVITY	DISTRIBUTION AREA, E/E DISTRIBUTION AREA, HVAC DISTRIBUTION AREA, PLUMBING
				CLOSET, E/E EQUIP.	
				CLOSET, HVAC EQUIP.	
				CLOSET, PLUMBING EQUIP.	
				CRAWL SPACE/UTILITY TUNNEL	ACCESS AREA CONTROL AREA DISTRIBUTION AREA, E/E DISTRIBUTION AREA, HVAC DISTRIBUTION AREA, PLUMBING
				EQUIP. ROOM	E/E EQUIP. AREA HVAC EQUIP. AREA PLUMBING EQUIP. AREA
				EQUIP. ROOM, ELEVATOR	
				EQUIP. ROOM, TELEPHONE	
				OFFICE, BLDG. ENGINEER	CONTROL MONITORING AREA WORK AREA
				UTILITY PENTHOUSE	E/E EQUIP. HVAC EQUIP. PLUMBING EQUIP.
				UTILITY SHAFT	E/E HVAC PLUMBING
				VAULT, ELECTRICAL	
	EXTERIOR	PRIMARY	CEREMONIAL	FLAG POLE AREA	
				MONUMENT AREA	

A PROPOSED HIERARCHICAL STRUCTURE
OF FUNCTIONAL SPACES FOR BUILDINGS

LEVEL I FACILITY TYPE	LEVEL II SPATIAL TYPE	LEVEL III FUNCTIONAL TYPE	LEVEL IV FUNCTIONAL GROUP	LEVEL V FUNCTIONAL SPACE,	LEVEL VI ACTIVITY SPACE
BACHELOR HOUSING	INTERIOR	PRIMARY	SOCIAL/RECREATION	LUNCH AREA	
				RECREATION ROOM	KITCHEN AREA
				VENDING AREA	MACHINE AREA SEATING AREA
		SUPPORT/SERVICES	ACCESS AREAS	CORRIDOR	
				ELEVATORS	
				LOBBY	
				STAIRS	
				VESTIBULE	
			SERVICE AREAS	CLOSET, JANITORS	
				INCINERATOR ROOM	
				LINEN ROOM	
				LOCKER ROOM	
				OFFICE, CONTROL	
				REFUSE ROOM	DISPOSAL AREA STORAGE AREA
				SHOWER ROOM	
				STORAGE, BLDG	
				STORAGE, LUMBER	
				STORAGE, PAINT	
				TOILET, MEN	LAVATORY AREA TOILET AREA
				TOILET, WOMEN	LAVATORY AREA REST AREA TOILET AREA
				VAULT, ARMS	STORAGE, ARMS

A PROPOSED HIERARCHICAL STRUCTURE
OF FUNCTIONAL SPACES FOR BUILDINGS

LEVEL I FACILITY TYPE	LEVEL II SPATIAL TYPE	LEVEL III FUNCTIONAL TYPE	LEVEL IV FUNCTIONAL GROUP	LEVEL V FUNCTIONAL SPACE,	LEVEL VI ACTIVITY SPACE
BACHELOR HOUSING	EXTERIOR	PRIMARY	CEREMONIAL	PARADE FIELD	PARADE AREA
					REVIEW AREA
			LANDSCAPE AREAS	BARRIER/SCREEN	BARRIER, PHYSICAL ACCESS
					SCREEN, VISUAL
					SCREEN,ACOUSTICAL
					SCREEN,CLIMATIC
				BUILDING SEPARATION	FRESH AIR CIRCULATION
					NATURAL LIGHT ENTRY
				FUTURE EXPANSION	
				VISTA/SETTING	BUILDING, SETTING
					LAND USE DEFINITION
					VISUAL RELIEF
			SOCIAL/RECREATION	COURT YARD	CIRC/CONVERSATION/REST
				PICNIC AREA	COOKING AREA
					EATING AREA
				SPORTS FACILITY	BASKETBALL COURT
					PUTTING GREEN
					SWIMMING POOL
					TENNIS COURT
					VOLLEY BALL COURT
				SPORTS FIELD	BASEBALL FIELD
					FOOTBALL FIELD
					HOCKEY FIELD
					SOCCER FIELD
		SUPPORT/SERVICES	ACCESS AREAS	EASEMENT	
				ENTRY AREA, PEDESTRIAN	LOBBY, EXTERIOR
					RAMPS
					STAIRS
				PARKING, AUTOMOBILE	
				PARKING, BICYCLE	
				PARKING, SERVICE/DELIVERY	
				PATHS, BICYCLE	

A PROPOSED HIERARCHICAL STRUCTURE
OF FUNCTIONAL SPACES FOR BUILDINGS

LEVEL I FACILITY TYPE	LEVEL II SPATIAL TYPE	LEVEL III FUNCTIONAL TYPE	LEVEL IV FUNCTIONAL GROUP	LEVEL V FUNCTIONAL SPACE,	LEVEL VI ACTIVITY SPACE
BACHELOR HOUSING	EXTERIOR	SUPPORT/SERVICES	ACCESS AREAS	ROADWAYS, AUTOMOBILE	
				ROADWAYS, EMERGENCY	
				ROADWAYS, SERVICE/DELIVERY	
				ROADWAYS, TRANSIT	BUS STOP TAXI STANDS TRAFFIC AREA
				WALKWAYS, PEDESTRIAN	COVERED WALKWAY RAMPS STAIRS WALKWAYS
			SERVICE AREAS	STORAGE YARD, EQUIPMENT	STORAGE,BUILDING MAINT EQUIP. STORAGE,SITE MAINT EQUIPMENT
				STORAGE,WASTE	STORAGE,RUBBISH
			UTILITY AREAS	DISPOSAL, STORM WATER	
				DISPOSAL, WASTE	
				DIST, SPACE, STORM WATER	
				DISTRIBUTION SPACE, E/E	
				DISTRIBUTION SPACE, GAS	
				DISTRIBUTION SPACE, WASTE	
				DISTRIBUTION SPACE, WATER	
				EQUIP, AREA E/E	
				EQUIP, AREA HVAC	
				EQUIP, AREA PLUMBING	
				STORAGE/SOURCE, WATER	
				STORAGE, FUEL	GAS PETROLEUM
				STORAGE, SANITARY WASTE	

A PROPOSED HIERARCHICAL STRUCTURE
OF FUNCTIONAL SPACES FOR BUILDINGS

LEVEL I FACILITY TYPE	LEVEL II SPATIAL TYPE	LEVEL III FUNCTIONAL TYPE	LEVEL IV FUNCTIONAL GROUP	LEVEL V FUNCTIONAL SPACE,	LEVEL VI ACTIVITY SPACE
BACHELOR HOUSING	EXTERIOR	SUPPORT/SERVICES	UTILITY AREAS	TREATMENT, WASTE	PRIMARY TREATMENT
					SECONDARY TREATMENT
					TERTIARY TREATMENT

APPENDIX C:

BUILDING COMPONENTS HIERARCHY

The building components hierarchy consists of several different levels that relate to material selection and specification. Each level represents a specific decision in the building design process, the lowest level indicating the basic construction task.

The structure displayed here is from Division 05 of the building components hierarchy.

Building Component Hierarchy for Roof Covering

5 0 0 0 0 0 0 0 0	ROOFING SYSTEM DEMO NUMBER 7
5 1 0 0 0 0 0 0 0	INSULATION
5 1 1 0 0 0 0 0 0	ABOVE DECK INSULATION
5 1 1 1 0 0 0 0 0	NAILABLE INSULATION
5 1 1 1 1 0 0 0 0	EXPANDED PERLITE BOARD(HH-I-529)
5 1 1 1 1 2 0 0 0	2 INCH
5 1 1 2 0 0 0 0 0	NON NAILABLE INSULATION
5 1 1 2 1 0 0 0 0	FOAMED CELLULAR GLASS (HH-I-551, TYPE IV)
5 1 2 0 0 0 0 0 0	BELOW DECK INSULATION
5 1 2 1 0 0 0 0 0	RIGID INSULATION
5 1 2 1 2 0 0 0 0	FIBERBOARD (LL-I-535, CLASS C)
5 1 2 1 2 1 0 0 0	1 INCH
5 1 2 3 0 0 0 0 0	ROLL/BATT (ASTM C-553)
5 1 2 3 6 0 0 0 0	3 IN
5 1 2 3 6 1 0 0 0	TYPE I
5 1 2 3 6 1 1 0 0	0.001 IN THICK AL FOIL
5 1 2 3 6 1 1 1 0	CLASS B1
5 2 0 0 0 0 0 0 0	VAPOR BARRIER
5 2 1 0 0 0 0 0 0	PAPER
5 2 1 1 0 0 0 0 0	SIALKRAFT
5 2 1 1 2 0 0 0 0	2 MIL THICK
5 2 3 0 0 0 0 0 0	ELASTOMETRIC
5 2 3 1 0 0 0 0 0	ROLL PLASTIC
5 2 3 1 1 0 0 0 0	4 MIL POLYVINYL
5 3 0 0 0 0 0 0 0	WATERPROOFING
5 3 1 0 0 0 0 0 0	BUILT UP BITUMINOUS
5 3 1 1 0 0 0 0 0	ROLL FELT
5 3 1 1 1 0 0 0 0	GLASS FIBER FELT
5 3 1 1 1 1 0 0 0	ASPHALT SATURATED FELT SS-R-520
5 3 1 1 1 1 1 0 0	TYPE I
5 3 1 1 2 0 0 0 0	ASBESTOS FIBER

5 3 1 1 2 1 0 0 0	ASPHALT SATURATED ASBESTOS FELT HH-R-590
5 3 1 1 2 1 1 0 0	TYPE I, CLASS A
5 3 1 1 3 0 0 0 0	ORGANIC FIBER
5 3 1 1 3 1 0 0 0	ASPHALT SATURATED ROOF FELT (HH-R-595)
5 3 1 1 3 1 1 0 0	ASPH SAT FELT HH-R-595 T II,CLASS 1(15)
5 3 1 1 3 2 0 0 0	ASPHALT SATURATED BASE SHEET (ASTM 2626)
5 3 1 1 3 2 1 0 0	TYPE I
5 3 1 1 3 3 0 0 0	COAL TAR SATURATED FELT (ASTM 227)
5 3 1 2 0 0 0 0 0	HOT COAL TAR PITCH(ASTM D 450,TYPE A)
5 3 1 2 2 0 0 0 0	20 LB/SQ
5 3 1 2 5 0 0 0 0	70 LB/SQ
5 3 1 3 0 0 0 0 0	HOT ASPHALT ASTM D-312
5 3 1 3 1 0 0 0 0	TYPE 1
5 3 1 3 1 2 0 0 0	20 LB/SQ
5 3 1 3 1 5 0 0 0	60 LB/SQ
5 3 1 3 2 0 0 0 0	TYPE 2
5 3 1 3 2 2 0 0 0	20 LB/SQ
5 3 1 3 2 4 0 0 0	50 LB/SQ
5 3 1 3 3 0 0 0 0	TYPE 3
5 3 1 3 3 2 0 0 0	20 LB/SQ
5 3 1 3 3 4 0 0 0	50 LB/SQ
5 3 1 4 0 0 0 0 0	AGGREGATE
5 3 1 4 3 0 0 0 0	ROOFING GRAVEL
5 3 1 4 3 2 0 0 0	400 LB/SQ
5 3 2 0 0 0 0 0 0	STRIP SHINGLES
5 3 2 1 0 0 0 0 0	FELT
5 3 2 1 1 0 0 0 0	ASPHALT-SATURATED ROOF FELT (HH-R-595,II,1)
5 3 2 2 0 0 0 0 0	REGULAR SHINGLES
5 3 2 2 1 0 0 0 0	ASPHALT SHINGLES (CLASS C)
5 3 2 2 1 1 0 0 0	TYPE 1
5 3 2 2 1 1 1 0 0	235 LB
5 3 2 3 0 0 0 0 0	WIND RESISTANT SHINGLES
5 3 2 3 1 0 0 0 0	ASPHALT CLASS C
5 3 2 3 1 1 0 0 0	TYPE 1-UNIFORM THICKNESS
5 3 2 3 1 1 1 0 0	235 LB

5 3 2 3 1 1 2 0 0	300 LB
5 3 3 0 0 0 0 0 0	ROLL ROOFING
5 3 3 1 0 0 0 0 0	MINERAL SURFACE ROLL ROOF
5 3 3 1 1 0 0 0 0	CLASS 1 90 LB ORGANIC
5 3 3 1 1 1 0 0 0	MOPPED
5 3 3 1 1 2 0 0 0	NAILED
5 3 3 2 0 0 0 0 0	SMOOTH SURFACE ROLL ROOF (ASTM D-224)
5 3 3 2 1 0 0 0 0	55 LB/SQ
5 3 5 0 0 0 0 0 0	BUILT UP ROOF ACCESSORIES
5 3 5 1 0 0 0 0 0	CEMENT AND ADHESIVES
5 3 5 1 1 0 0 0 0	BITUMINOUS CEMENT SS-C-153
5 3 5 1 1 1 0 0 0	TYPE I
5 3 5 1 1 2 0 0 0	TYPE II
5 3 5 2 0 0 0 0 0	CANTS
5 3 5 2 3 0 0 0 0	WOOD, MOISTURE TREATED
5 3 5 2 3 1 0 0 0	6 IN X 6 IN TRIANGLE
5 3 5 3 0 0 0 0 0	NAILING STRIPS
5 3 5 3 1 0 0 0 0	1 X 6 IN TREATED WOOD W/VENT
5 4 0 0 0 0 0 0 0	FLASHINGS
5 4 3 0 0 0 0 0 0	GALVANIZED
5 4 3 2 0 0 0 0 0	GRAVEL STOP
5 4 3 2 2 0 0 0 0	1 IN HIGH
5 4 3 5 0 0 0 0 0	REGLETS
5 4 3 5 1 0 0 0 0	ATTACHED TO WALL
5 5 0 0 0 0 0 0 0	DRAINAGE
5 5 1 0 0 0 0 0 0	GUTTER TROUGH
5 5 1 1 0 0 0 0 0	4 INCH GUTTER TROUGH
5 5 1 1 1 0 0 0 0	4 INCH ALUMINUM GUTTER TROUGH
5 5 2 0 0 0 0 0 0	ENDS
5 5 2 1 0 0 0 0 0	4 INCH ENDS
5 5 2 1 1 0 0 0 0	4 INCH ALUMINUM ENDS
5 5 3 0 0 0 0 0 0	DOWNSPOUTS
5 5 3 1 0 0 0 0 0	4 INCH DOWNSPOUTS
5 5 3 1 1 0 0 0 0	4 INCH ALUMINUM DOWNSPOUTS

5 5 4 0 0 0 0 0 0	STRAINERS
5 5 4 1 0 0 0 0 0	4 INCH STRAINERS
5 5 4 1 1 0 0 0 0	4 INCH ALUMINUM STRAINERS
5 7 0 0 0 0 0 0 0	UNDERLAYMENT
5 7 1 0 0 0 0 0 0	NON NAILABLE
5 7 2 0 0 0 0 0 0	NAILABLE

APPENDIX D:

CATEGORICAL CRITERIA MATRIX

This appendix demonstrates the organization of standard design criteria into ten unique categories. As a prototypical model, data were taken from TM 5-805-14, Roofing Design, and a Design Guide an officer's open mess and structured into the "Categorical Criteria Matrix." This study was undertaken to:

1. Determine which criteria have regulatory authority
2. Determine what portion of current criteria documents are relevant to designer tasks
3. Determine if a criteria has spatial or component significance.
4. Develop a simpler, more logical notation for the criteria that would facilitate the development of a computer-based data structure.

Special emphasis should be given to item 4, the new notation of the criteria. The format developed expresses design criteria in terms of a conditional expression which can be used as an internal storage notation in the automation of the design criteria management and evaluation processes.

The ten categories refer to any combination of regulatory or nonregulatory authority in combination with spatial and/or component significance or any relationship between these two factors and deterministic parameters such as design life, geometric constraints, and personnel. The ten unique categories of criteria are:

1. Regulatory spatial criteria
2. Regulatory component criteria
3. Regulatory spatial/component criteria
4. Regulatory spatial/parameter criteria
5. Regulatory component/parameter criteria
6. Nonregulatory spatial criteria
7. Nonregulatory component criteria
8. Nonregulatory spatial/component criteria
9. Nonregulatory spatial/parameter criteria
10. Nonregulatory component/parameter criteria

The internal structure for design criteria is not restricted by this categorical breakdown. The categories portray the design criteria as sets of data that allow internal structuring to take place in a more logical framework.

Only parts of TM 5-805-14 and the Design Guide have been reformatted here. The purpose was not to restructure an entire document but to demonstrate the concept and examine its feasibility.

The criteria have been located in the proper categories on the matrix and expressed as conditional statements. Their location in the source documents is indicated.

CATEGORICAL CRITERIA MATRIX

Criteria Source	R	NR	S-S	C-C	S-C	S-P	C-P	Conditional Expression
TM5-805-14 par. 2a		✓					✓	parm = design life If(des.life=perm) then [(memb)=5B.U.)and(felt=org)] or [(memb)=4B.U.)and(felt=glass)]
TM5-805-14 par. 2a		✓					✓	parm = design life If(des.life=semi) then [(memb=4B.U.)and(felt=org)] or[(memb=3B.U.)and(felt=glass)] or(memb=shingles)
TM5-805-14 par.2a							✓	parm = design life If(des.life=temp) then (memb=roll) or[(memb=3 B.U.) and (felt=organic)]
TM5-805-14 par. 2a		✓					✓	parm = slope If (slope ≤ 1) then (memb = B.U.)
TM5-805-14 par 2b		✓		✓			✓	parm = slope If (memb=5ACS or 4ACGS) and [(deck=strck.conc.) or (insul.type=board)] and (slope=<1) and (bit.=asph.) then (anchorage=no)

LEGEND: R-regulatory; NR-non-regulatory; S-sptial; C-component; P-parameter

CATEGORICAL CRITERIA MATRIX

Criteria Source	R	NR	S-S	C-C	S-C	S-P	C-P	Conditional Expression
TM5-805-14 par. 2b		✓					✓	parm = slope If (slope< 1/2) then error
TM5-805-14 par. 2b		✓					✓	parm = slope If(1/2<slope 1) Then (memb = B.U.) else if (1<slope<2) then (memb=B.U.) or (Memb= roll selvage) else if (2<slope<3) then (memb=B.U.) or (memb=roll) else if (slope<3) then (memb=shing) or (memb =corr.metal) or (memb =corr.asbestos cement)
TM5-805-14 par.2.c.1		✓					✓	parm = temp If (temp< -10°) and (slope>1) then (memb-B.U.) or (memb=shingles)
TM5-805-14 par. 2.c.4		✓					✓	parm = wind, slope If(wind<40) and (slope>4) then (shingles=standard) else (shingles=wind resistent)

LEGEND: R-regulatory; NR-non-regulatory; S-spatial; C-component; P-parameter

CATEGORICAL CRITERIA MATRIX

Criteria Source	R	NR	S-S	C-C	S-C	S-P	C-P	Conditional Expression
TM5-805-14 par. 4.a.1		✓		✓				if (memb=B.U.) then (deck = wood or gypsum or strck. conc. or insul. conc. or board type insul.) or [(deck=metal) and(insul.=board type) and(insul.loc.=above)]
TM5-805-14		✓		✓				if (insul=board type) then (memb=temp)
TM5-805-14 par. 4.b.1		✓		✓			✓	parm = slope if (memb-single) and (slope 4) then (felt =2 layer) esle if (slope 4) then (felt = 1 layer)
TM 5-805-14 par. 4.b.2		✓		✓				if (memb=shingle) then (vapro barr. = no)
TM5-805-14 par. 4.c.1		✓					✓	parm = design life if (des.life=perm) or (des.life=semi) then (memb=roll)

LEGEND: R-regulatory; NR-non-regulatory; S-spatial; C-component; P-parameter

CATEGORICAL CRITERIA MATRIX

Criteria Source	R	NR	S-S	C-C	S-C	S-P	C-P	Conditional Expression
TM 5-805-14 par. 5.a		✓		✓				if (member = B.U.) then (Insul. type-board)
TM5-805-14 par. 5.d		✓		✓				if (insul.=yes) or (underlayment=yes) then (venting-yes)
TM5-805-14 par. 6.b		✓					✓	parm = traffic type if (traffic=promen.) then (memb=5TCS with aggragate removed) and (insul = no)
DG-Open Mess Space: Bar	✓					✓		parm = subspace If(space-banquet) and subspace=service) then (subspace=mobil bar)
DG-Open Mess Space: Bar	✓					✓	✓	parm = personnel If(subspace=service bar) and (pers=1 man) then (bar length = 6'-8')

LEGEND: R-regulatory; NR-non-regulatory; S-spatial; C-component; P-parameter

CATEGORICAL CRITERIA MATRIX

Criteria Source	R	NR	S-S	C-C	S-C	S-P	C-P	Conditional Expression
DG-Open Mess Space: Bar	✓				✓			if (space=bar) then ((diagram=3) and refer to diagram
DG - Open Mess Space: Bar		✓	✓					If (space=bar) then [fl. area(bar) =[7-12% fl. area(tac)]

LEGEND: R-regulatory; NR-non-regulatory; S-spatial; C-component; P-parameter

APPENDIX E:

FACILITY DESIGN CRITERIA HIERARCHY

This example hierarchy indicates how the two criteria hierarchies could conceptually be linked. The functional space hierarchy is used in the initial phases to integrate with the A/E schematic design process. Architects are involved first with the manipulation of spaces and then with those elements that give the spaces definition.

The most reasonable level of the spatial hierarchy to work with in schematic design and/or design development is Level V, Functional Space. By designing and manipulating space at this level the A/E can either:

1. Branch down to Level VI and deal with specific activities and systems, etc., that are involved with that specific setting, or

2. Define the building components and systems that relate directly to the Level V space, or a combination of Level VI spaces, or

3. Combine Level V space descriptions and the appropriate component information that is associated into any facility type.

The proposed structure has been developed to relate well to programmer, designer, and reviewer while accommodating existing data sources. It is constructed to work with normal professional design procedures as well as with logical program development. The broad-scope to narrow-scope structure is intended to permit the A/E first receiving data to absorb it in a logical way. Later, it is structured to allow him to move successively through the data or to selectively skip portions, depending on his need.

The example displays the conceptual linked hierarchy with the component hierarchy embedded in the spatial hierarchy at the Level IV, V, and VI descriptors. The data represented is for a bachelor housing facility and is presented not as a solution but only as an indication of the concept.

LEVEL I

FACILITY TYPE

BACHELORS HOUSING

Philosophy:

BOQ's due to economy shall be of large capacity (100 persons or more). They shall be located on sites which allow for a relaxing view.

Use:

The BOQ's shall be used as personal residences of Enlisted officers in grades 02 and below and grades 03 and above.

Relationships:

The BOQ should be located so as to be easily accessible to all installation facilities. It should have direct access to classroom and administration facilities.

LEVEL II

SPATIAL TYPE

ENCLOSED

Philosophy:

The rooms of the BOQ should be arranged on a double loaded corridor in clusters of not less than four units.

Size:

The story height shall not exceed 10'-0". The total building height should be designed to practical minimum taking into account the optimum cast trade offs with structural and mechanical systems.

LEVEL III

FUNCTIONAL TYPE

USER

Philosophy:

The officers using the residence is usually between the age of 22 and 27 years old and views his apartment the same way that a civilian does.

Size:

The user shall consist of officers in Grades 02 and below, and Grades 03 and above.

250 offices shall reside in one complex.

LEVEL IV

FUNCTIONAL GROUP

RESIDENCE

Philosophy:

The residence should allow for the officers to relax in private whether reading a book, watching television, or listening to his stereo. It also should allow for him to socialize with fellow officers or visiting friends, whether from the facility or not.

Relationship:

The residence should be relatively close to the common lounge space and clothes washing area of the BOQ. Each residence should house no more than tow (2) occupants.

Size:

Officers in Grades 02 and below shall have a residence of approximately 330 square feet consisting of a combination living/dining, bath and pullman type kitchen.

Officers in Grades 03 and above shall have a residence of approximately 460 square feet consisting of a living room, bedroom, bathroom and kitchen.

General Design Criteria:

Maximum story height 10'-0"

Interior doors

a. 2'-8" x 6'-8" minimum
b. Swing door to have 90" minimum swing.

Windows (including sliding glass doors)
a. Minimum area 10% of floor area served.
b. Minimum operable 5% of floor area served.
c. Maximum area 30% of floor area served.

Structural Criteria:

Design loads

Static or Dead Loads

All structural elements shall be designed to safely support all dead loads, permanent or temporary, including self weight, partitions (minimum of 10 PSF) roofing, insulation, ceilings, floor covering and mechanical equipment.

Vertical Live Loads
a. Roof: 20 PSF
b. Floors: 40 PSF

LEVEL V

FUNCTIONAL SPACE

LIVING AREA

Philosophy:

Each living unit shall contain space that is conducive to general living activities, among which are entertaining, reading, writing, listening to music, watching television and relaxing. Unless specifically provided elsewhere in the unit, the above listed activities will be contained in the living unit.

Relationship:

It should be directly accessible to the kitchen, dining area and required exits. It also should be accessible to the sleeping area and bath without passing through any habitable area.

Size:

a. Minimum width 11 feet 0 inches
b. Minimum area 160 square feet
c. Ceiling height minimum 8'-0"
d. Occupancy two (2) minimum

Mechanical Criteria:

a. Electric baseboard units shall be provided.

Electrical Criteria:

a. A switched outlet shall be provided for each living unit.
b. Receptacles shall be no more than 12 feet apart.
c. A master TV antenna outlet should be provided.

Lighting Criteria:

If the dining area is included in the living area, provide an overhead switched light.

DINING AREA

Philosophy:

Each living unit shall contain space for the purpose of dining. This area may be combined with the living room or kitchen, or may possibly be a separate space.

Relationship:

The dining area shall be directly accessible to the kitchen and living area. It should also be accessible to the bathroom without passing through any habitable area.

LEVEL VI

ACTIVITY SPACE

LIVING AREA

CONVERSATION AREA

A desirable conversation distance is of relatively small size approximately 10 feet in diameter.

STORAGE AREA

Provide 12 lineal feet of shelving for books, records, stereo, TV, etc.

EATING AREA

1 - 42" round table, 4 chairs.
Passage area 24"

STORAGE AREA

Storage Unit 1'-6" x 3'-6"

LEVEL IV	LEVEL V	LEVEL VI
FUNCTIONAL GROUP	**FUNCTIONAL SPACE**	**ACTIVITY SPACE**

Horizontal Load (acting inward or outward)
- a. On exterior walls: 25 PSF
- b. On interior walls or partitions: 10 PSF

Seismic Load
- a. Seismic Zone #2

Size:

- a. Minimum area
  1. 80 sq. ft. if a separate area
  2. 40 sq. ft. if combined with living area
  3. 40 sq. ft. if combined with the kitchen area
- b. Ceiling height minimum 8'-0"
- c. Occupancy two (2) minimum

Electrical Criteria:

Duplex outlet for eating apparatus.

Lighting Criteria:

Provide one overhead switched light for dining table.

Atmospheric Environment:

Exterior Wall

"U" Factor
- a. (without glazing or doors) 0.15 BTU/hr./sq. ft. maximum.
- b. (doors and glazing) 0.56 BTUH/hr./sq. ft. maximum

No settlement or compaction of insulation due to vibration.

Vapor penetration: Provide barrier having permanence of 1 perm minimum. ASTM E-26. Locate to allow passage of interior services within controlled environment.

Moisture Penetration: No moisture drawn to interior surface. ASTM-E331.

Air Infiltration: ASTM-E283
- a. 0.06 CFM/Sq. Ft. of exposed wall
- b. 0.5 CFM/Lin. ft. of door frame
- c. 0.5 CFM/Lin. ft. of operable sash perimeter maximum.

Roof/Ceiling

"U" factor 0.07 BTUH/hr./sq. ft. maximum

No entrapment of moisture.

Provide vapor barrier in flat or near flat roof construction.

Provide ventilation of attic spaces. Vent area equal to 1/150 minimum of horizontal projection of roof area.

Floor/Ceiling

"U" factor (floor exposed to exterior): Match requirement for exterior wall, Pef. Sub-System II.

No entrapment of moisture.

Heating, Ventilating and Air Conditioning:

KITCHEN/KITCHENETTE

Philosophy:

The basic activities in the kitchen consist of food preparation, serving and cleanup after the meal. The kitchen area shall permit the efficient operation in the performance of these functions. In addition space shall be provided for staples, dinnerware and utensils.

Relationship:

The kitchen area shall be directly accessible to the dining area, living area and required exit. It also shall be accessible to the bathroom without passing through any habitable room.

Size:

- a. Minimum area 120 sq. ft.
- b. Ceiling height minimum 7'-0"
- c. Occupancy two (2) minimum

General Criteria:

Ceiling height minimum 7'-0".

Mechanical Criteria:

There should be intermittant mechanical exhaust for range hoods.

Plumbing Criteria:

If gas cooking is utilized, a gas service should be provided.

Electrical Criteria:

Two appliance circuits should be provided for each kitchen unit.

Outlets will be provided for cooking equipment and shall be individually circuited.

Food Preparation Area:

Base/Wall Catinests: 25 Cu. Ft.

Burner Unit: 30" unit with mechanical exhaust.

Oven Unit: 2.7 Cu. Ft. minimum dimension 15".

Refrigeration: W/freezer capacity 8 Cu. Ft.

Sink: Minimum capacity 96 Cu. Ft. Depth 6'-8". Minimum 2-1/2 Lin. Ft. of counter space. Acid resistant porcelain or 18 gauge #304 stainless steel.

Shelving: 15 lin. ft.

Eating Area:

Table w/Chairs: Minimum table dimension 4'-0".

LEVEL IV

FUNCTIONAL GROUP

Atmospheric Criteria

Heating
a. Outside temperature 8 degrees F.
b. Inside temperature 72 degrees F.

Cooling
a. Outside temperature 93 degrees F.
b. Inside temperature 78 degrees F.

Relative Humidity
a. Outside W.B. temperature 78
b. Inside 50% N.C.

Outside Air: 75 CFM per sq. ft. minimum.

Air Changes
a. 7.5 per hour minimum.
b. 15 per hour maximum.

Air Movement 50 FPM

Air filter efficiency: 10% - 15%.

Design population per BOQ Unit: 2

Mechanical Services

Exhaust
a. Individual thermostatic control for each BOQ Unit.

Acoustic Criteria:
a. Ambient Noise Level: NC 25 36
b. Provide speech privacy between BOQ units.

Electrical/Electronic

Power

Individual load centers will be installed for each unit.

Receptacles will be circuited together.

Lighting will be circuited together.

All wiring in accordance with minimum requirements of the NEC.

Lighting

General

All other lighting will be incandescent with special emphasis on make up and reading areas.

Ample wall toggle switches will be installed for proper control of lighting.

Television
a. One television reception outlet will be installed for each unit.

Telephone
a. One telephone outlet will be installed for each unit.

Fire Detection System

LEVEL V

FUNCTIONAL SPACE

Lighting Criteria:

Fluorescent luminaires should be utilized for a maintained level of 60 foot candles.

Warm white lamps shall be installed in the fixtures.

BEDROOM AREA(SLEEPING AREA)

Philosophy:

Each living unit shall have a space (open or enclosed) allocated to sleeping and related activities as dressing, personal care, reading and studying. Sufficient space shall be provided for clothes storage.

Relationship:

It shall have direct access to the bathroom area, without passing through any habitable room.

Size:

a. Minimum width 8'-6".
b. Minimim area 120 sq. ft. (if enclosed)
c. Minimum ceiling height 8'

Functional Criteria:

The location of doors, windows and closet shall be planned to facilitate placement of the bed and other furniture.

Placements of the closet near the door in the bedroom minimizes the use of wall space.

Mechanical Criteria:

a. Provide electric base board heat. 8 lineal feet, a 400 watts/foot.

Electrical Criteria:

a. Provide one switched outlet.
b. Provide duplex outlets 12 feet minimum apart.

Lighting Criteria:

a. Provide a light with pull chain in closet.

Sonic Criteria:

a. Auditory privacy is required for all bedrooms minimum STC rating of 45.

LEVEL VI

ACTIVITY SPACE

Sleeping Area:

3'-0" x 7'-0" minimum sleeping area/man lounge chair.

Storage Closet:

5'-0" lin. ft. (rod) hanging space.

5'-0" lin. ft. (shelf) space.

Fixed or movable.

LEVEL IV

FUNCTIONAL GROUP

Acoustic Environment:

Exterior Wall

Wall (without glazing or doors) Sound Transmission Class (STC) 42. ASTM-E90.

Wall (with glazing excluding doors) Sound Transmission Class (STC) 27. ASTM-E90.

Roof Ceiling

Sound Transmission Class (STC) Meet requirement for exterior wall. Ref. Sub-System II.

Impact Sound Pressure Level: Meet recommendation curve of F.H.A. Guide No. 750.

Interior Wall

Sound transition Class (STC) 42 minimum (without doors) ASTM-E90.

Sound Transmission Class (STC) 24. Minimum for doors.

Luminous Environment:

Exterior Wall

Illuminated Environment
- a. Vision through glazing to be undistorted.
- b. Glass shall pass 56% of visible light, minimum.

Roof Ceiling

Illuminated Environment
- a. Ceiling reflection 70% minimum.

Floor Ceiling

Illuminated Environment
- a. Ceiling Reflectance: Ref. Roof/Ceiling Sub-System II.
- b. Floor Reflectance: 35% minimum.

Interior Wall

Illuminated Environment
- a. Glass Rating: Maximum 20. Gardner 60° Glossmeter.

Safety and Convenience:

Exterior Wall

Fire Safety

Fire Containment: ASTM-E119
- a. Load Bearing: Non-combustible
- b. Non-Load Bearing: Non-combustible

Flame Spread: ASTM-E84
- a. Exterior Surface: 200 Maximum.
- b. Interior Surface: Meet requirements for interior partition.
- c. Insulation: 25 maximum.

LEVEL V

FUNCTIONAL SPACE

BATHROOM

Philosophy:

Bathrooms shall be adequate for a water closet, lavatory and tub or shower. Arrangement for fixtures shall provide for the comfortable use of each fixture and permit a minimum 90° door swing.

If residence space has two occupants, the lavatory shall be in a separate space allowing for the private use of the water closet and tub or shower.

Relationship:

The bathroom shall be directly accessible to the bedroom and/or living/sleeping area without passing through any habitable area.

Size:

- a. Minimum area 35 square feet.
- b. Minimum ceiling height 7 feet.
- c. Occupancy two (2) minimum.

Mechanical Criteria:

- a. There shall be intermittant mechanical exhaust 200 CFM.

Electrical Criteria:

- a. Provide a duplex outlet above sink counter.

Lighting Criteria:

- a. Provide switched overhead light.
- b. Provide switched overhead infra-red drying lamp.

Plumbing Criteria:

- a. Provide mixing valve for shower 140° F. maximum.

HALL/ENTRY AREA

Philosophy:

The hallway and/or entry area shall be a transitioned space between habitable rooms and shall allow for the easy access between these spaces.

Relationship:

LEVEL VI

ACTIVITY SPACE

Fixture Area - Provide the following:

Water Closet
Lavatory
Bath tub and/or shower
Towel rod
Paper Dispenser
Medicine Cabinet
Towel Storage

LEVEL IV

FUNCTIONAL GROUP

LEVEL V

FUNCTIONAL SPACE

LEVEL VI

ACTIVITY SPACE

Smoke Generation: ASTM STP 442
- a. Exterior Surface: 450 maximum optical density.
- b. Interior Surface: Meet requirements for interior partitions.
- c. Insulation: 50 maximum optical density.

Potential Heat: 8000 VTU for any square foot of wall section. ASTM proceedings 61.

Transmission of fire and smoke from one floor to another to be prevented.

Roof/Ceiling

Fire Safety

Fire Containment: Non-combustible. ASTM-E119.

Flame Spread:
- a. Roofing: Class C or better. ASTM-E108.
- b. Ceiling: *75 maximum.* ASTM-E84.
- c. Roof used as walking surface: 75 maximum. ASTM-E84.
- d. Insulation: *25 maximum.* ASTM-E84.

Smoke Generation: ASTM STP 422.
- a. Ceiling: Maximum optical density 150.
- b. Insulation: *Maximum optical* density 50.

Potential Heat: 5,000 BTU *maximum* for any square foot of roof ceiling section. ASTM Proceedings 61.

Floor/Ceiling

Fire Safety

Fire Containment: Non-combustible ASTM-E119.

Flame Spread: ASTM-E84.
- a. Floor Covering: 200 Maximum.
- b. Ceilings: Match requirement for roof/ceiling Ref. Sub-System III.
- c. Insulation: Match requirement for roof/ceiling. Ref. Sub-System III.

Smoke Generation: ASTM STP422
- a. Floor Covering: Maximum optical density 450.
- b. Ceiling: Match requirement for roof/ceiling. Ref. Sub-System III.
- c. Insulation: Match requirement *for roof/ceiling. Ref. Sub-*System III.

Potential Heat: 5,000 BTU maximum for any square foor of floor/ceiling section. ASTM Proceedings 61.

Interior Wall

Fire Safety

Fire Containment. ASTM E-119.
- *a. Load Bearings: Non-combustible.*

The entry area shall be directly accessible the primary required exit and the kitchen *and living area.*

The hall shall allow access from the bedroom/bath are to the living area and exitway.

Size:

- a. Minimum width 3 feet.
- b. Minimum ceiling height 7 feet.

Electrical Criteria:

- a. Provide duplex outlet for cleaning.

Lighting Criteria:

- a. Provide switched overhead lighting fixture if size of space requires one.

APPENDIX F:

FORMATS

One goal of information management in the design process is to transmit information in a format that relates design criteria to the phase or phases of the process where they fit.

Architects, possibly because of their training and close involvement with visual information in the form of drawings during their work, tend to prefer information presented through visual formats.[22] Visual information can be a much more economical means of presenting certain sorts of social and technical information. Tables and charts, for example, can illustrate points much more clearly than words alone could. Also, and most importantly, visual communication often presents information in the form in which it will be used.

Reducing the level of abstraction of visual communication demands that verbal information be effectively integrated. The relationship between text and illustrations is important. For practical purposes it is important to have diagrams and text correctly juxtaposed.[23]

The following examples of criteria communication (from *Architects and Information*) employ visual/verbal formats and indicate the directions proposed for the hardcopy facility design criteria file generated by Subsystem Three of the DCMS.

[22] James Goodey and Kate Matthews, *Architects and Information*, Research Paper 1 (Institute of Advanced Architectural Studies, University of York, England, 1971), p 48.
[23] Goodey and Matthews, p 35.

A ventilation system for internal bathrooms and WCs in multi-storey dwellings

A recommended standard design for a simple mechanical extract ventilation system for multi-storey housing. The design is intended mainly for flats and is adaptable to buildings of various heights. Examples are given of buildings up to 21 storeys.

The system consists of one or more vertical ventilation stacks and extract fans with a branch (or 'shunt') connected to a simple grille or orifice in every room being ventilated. The system is accommodated, with other services, in a vertical service duct. The stacks and shunts are formed of extruded PVC tube, of the kind used for soil and waste installations.

Introduction

It is becoming more usual in multi-storey housing for bathrooms and WCs to be placed not on the external walls but internally. Where this is done a need is created for some kind of extract ventilation.

In most multi-storey housing projects plans are repeated floor by floor, with bathrooms and WCs located one above the other. This offers scope for standardising the mechanical services and, consequently, economising on labour and cost, reducing site work, and ensuring more efficient design and performance.

Field studies showed that many extract ventilation systems in existing buildings do not perform well, for various reasons.

The recommendations made here are based on a full-scale experiment, which included measures of pressures and ventilation rates and a user survey. This last showed that the conditions provided were acceptable; some noises were transmitted through the system but did not cause complaint.

The system

The system consists of one or more vertical ventilation stacks and extract fans with a branch (or 'shunt') connected to a simple grille or orifice in every room being ventilated. The system is accommodated with other services in a vertical service duct. The stacks and shunts are formed of extruded PVC tube of the kind used for soil and waste installations. PVC tubing is easy to handle and install and experience in its use has shown that a 'tight' system is obtained when the joints are assembled correctly.

Vertical ventilation stack

A typical layout of the main ventilation stack and its connections is shown in **figure 1**. The material is extruded PVC tube for industrial use BS 3506 1962, 150 mm bore with spigot and socket joints. Each joint includes a flexible seal made of a synthetic rubber O-ring, supplied by the manufacturer, and constitutes an expansion joint. The stack is fixed to the structure by holderbats below each joint. (See **figure 2**). The holderbats should be made of steel with a protective coating.

Shunts

Shunts are 75 mm dia. PVC, not less than 900 mm long, connected to the vertical stack at an angle of 45°. Note the special arrangements that may have to be made at the topmost floor (**figure 3**). Back-to-back connections to a single main stack are not recommended.

Room outlets

Only one type of outlet need be used. If the bathroom and WC are combined, then a plain orifice 44 mm dia. is sufficient. Flats planned with WC separate from bathroom need a 31 mm orifice in each space. In this case a T-piece can provide a single connection to the branch. Where maisonettes have outlets on separate floors, separate shunts are needed. A grille may be used instead of an orifice but the design will be more complicated.

Balancing damper

The only fitting needed to control the rate of air flow up the stack is a variable aperture (i.e. a 'balancing damper') sited near the top of each stack.

Use of multiple ventilation stacks

All these parts of the system are contained in:

Services ducts

Vertical services ducts are positioned in relation to bathrooms and WCs similarly to the one shown in **figure 4**.

The position of particular services within this space may be critical: for example, the soil and waste stack will probably demand priority. A convenient position for the ventilation stack and shunts is indicated in **figure 5**.

A fire-resisting duct casing (e.g. 10 mm thick insulating board on timber battens) is recommended in all cases. A concrete floor stop (**figure 2**) (i.e. concrete fill around the services at the level of the structural floor) is also desirable. Floor stops improve sound insulation and provide a rigid fixing for the services while allowing flexibility in positioning.

At the top of the building are the:

Fan and housing

Ventilation stacks may discharge separately or in groups, i.e. two or more stacks can be brought together (via a 'collecting box') and connected to a common fan via a roof-top main.

The fans require weatherproof casings or simple protective housings. For individual fan units these may be provided by the fan manufacturer. Otherwise, the fan manufacturer will normally suggest minimum dimensions, positions of access, etc., for the fan housing.

A duplicate fan with changeover damper is required by certain local authorities.

To specify the fan it is necessary to state the total flow required and the minimum static pressure. The figure for total flow is obtained by multiplying the total number of dwellings by the flow per dwelling (**table I**).

The minimum fan static pressure required is given in **table II**. To this should be added any losses in roof mains and so it is necessary first to determine the layout. A suitable loss figure can then be obtained by multiplying the length of the longest roof main by the figure given in **table III** which also gives the roof main diameter, and losses in bends.

Other applications

Buildings higher than eight storeys could be ventilated by two or more 150 mm main ventilation stacks, (**figure 6**) the maximum number of dwellings connected to each stack being limited as shown in **table IV**.

For flats that have one or two WCs, and for maisonettes, the maximum number of connections to the stack is given in **table V**.

The system is not suitable for the ventilation of internal kitchens because grease may accumulate in the ducting.

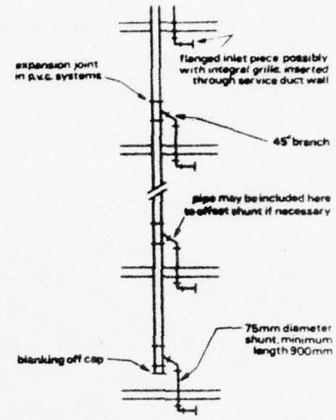


Figure 1

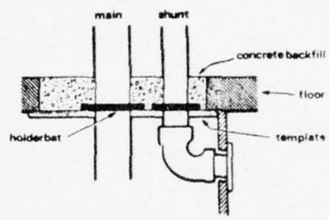


Figure 2

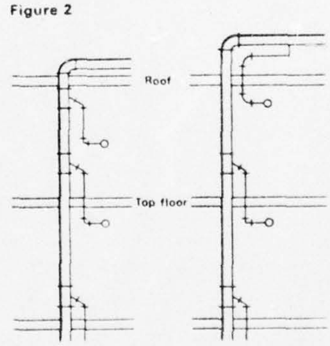
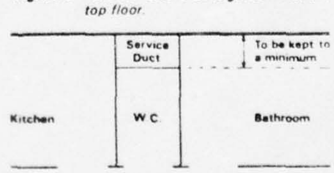


Figure 3 *Possible shunt arrangements at the top floor.*



Position of service duct

Figure 4

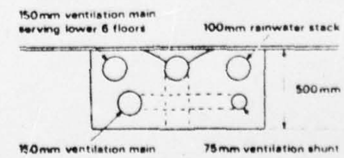


Figure 5

Total air flow required

Dwellings with	flow per dwelling
1 WC	50 m^3/h
2 WC	75 m^3/h

Table I

Pressure losses in mains and branches

No of storeys (inclusive)	minimum fan static pressure for systems serving	
	Flats	Maisonettes
up to 7	125 N/m^2	125 N/m^2
8 to 13	185 N/m^2	185 N/m^2
14 to 19	210 N/m^2	185 N/m^2
over 19	250 N/m^2	210 N/m^2

(*Note:* a loss at the exhaust cowls of 50 N/m^2 is assumed. Any loss in excess of this should be added.)

Table II

Roof main diameters and losses

Total flow not greater than (m^3/h)	440	780	1220	1760	2400	3130	3960
Diameter of roof main (mm)	150	200	250	300	350	400	450
Loss per metre of roof mains (N/m^2)	4	3	2	1·6	1·4	1·2	0·8
Loss per right angle bend in roof mains (N/m^2)	8·6	8·6	7·2	6·9	7·0	6·8	5·2

Table III

Type of dwelling	Maximum number of dwellings to be connected to a single 150mm main duct
1 Flats with combined bth/WC, or with one WC and separate bathroom	8
2 Flats with combined bth/WC and separate WC	6
3 Maisonettes with combined bathroom/WC, or with one WC and separate bathroom	6
4 Maisonettes with combined bth/WC and separate WC	5

Table IV Number of connections to a 150mm main duct with different types of dwelling.

Note. Not back-to-back connections.

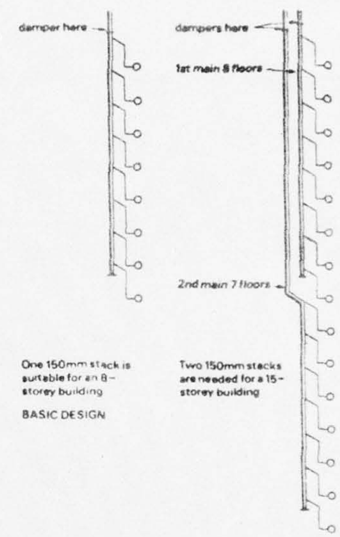


Figure 6 *Use of multiple ventilation stacks in taller buildings, the examples are based on table V and dwellings of type 1*

Type of dwelling		Number of superimposed dwellings 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1 Flats with combined bathroom/WC (or with 1 WC and separate bathroom)		**2**	**3**	4	5	6	7	8	5	6	7	8	8	8	8	**8**	8	8	8	8	8
	Second main								→4	4	4	4	5	6	7	**4**	**5**	**6**	7	7	7
	Third main															→**4**	4	4	4	5	6
2 Flats with combined bathroom/WC and separate WC		**2**	**3**	4	5	6	4	5	6	6	6	6	6	6	6						
	Second main						→3	3	3	4	5	3	4	5	5						
	Third main											→3	3	3	**4**						
3 *Maisonettes* with combined bathroom/WC (or with 1 WC and separate bathroom)		**2**	**3**	[illegible]	5	6	4	5	6	6	6										
	Second main						→3	3	3	4	5										
4 Maisonettes with combined bathroom/WC and separate WC		**2**	**3**	4	5	4	4	5	5	6	6										
	Second main					→2	3	3	4	2	3										
	Third main									→2	2										

Notes
1. Numbers in **bold** may be served by 100mm system
2. *Minimum extract rate* 43m^3/s per dwelling
3. Maximum storey height 2,900mm
4. The topmost main is designated first

Table V Number of connections to each main for 150mm standard system

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